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DEVELOPING AND DEMONSTRATING AN INSTITUTIONAL MECHANISM FOR TRANSFERRING REMOTE SENSING TECHNOLOGY TO 14 WESTERN STATES USING NORTHERN CALIFORNIA AS THE TEST SITE.

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REMOTE SENSING AND TECHNOLOGY TRANSFER PROJECT

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Kotim Een Karuk Ceremonial Society

Multi Cultural Education Project

N A S A Remote Sensing Technology Transfer Project

National American Indian Repertory Theatre Project

Northern California Health Systems Agency Support Project

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FINAL REPORT
COVERING PERIOD
JUNE 1, 1977 THROUGH DECEMBER 31, 1978

DONNA HANKINS
PRINCIPAL INVESTIGATOR
NASA GRANT 2244

Report No. 3

224 p.

IN COOPERATION WITH CALIFORNIA'S NORTHWEST COUNTIES

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ABSTRACT

The period of grant activity (June 1, 1977 through December 31, 1978) has seen dynamic results from wise use of NASA "seed" dollars in the Northern California Remote Sensing and Technology Transfer Project at Humboldt State University. The grant, while broad in its scope, has effectively provided the Northern California community with the means to create, design and implement a strong working model for remote sensing technology transfer.

From the beginning, the northern California group has utilized a three-part approach, essential to a comprehensive transfer program, including the university and community college, the "community" at large, and potential/actual direct user agencies, primarily state and local.

Each of three areas of approach, using the specific activities described in this document, have addressed eight stated goals and objectives, and in multiple ways. Each of the stated eight barriers to technology transfer was recognized as an initial guideline, which in removing, helped to achieve the goals and objectives. All project activities were designed to help remove traditional constraints, whether real or implied, that have hampered technology transfer efforts in the past.

The model, designed to serve local, regional and national needs, is still in a formative stage, needing further development, testing and evaluation before transfer to an operational mode.

Analysis of the activities and accomplishments within each of the three major transfer effort areas has identified the essential next steps.

These steps include the following:

--Complete transfer of a remote sensing capability to Humboldt State University.

* Integrate computer processing of remotely sensed data with a demonstration course.
* Integrate remote sensing training with activities of the Office of Continuing Education.

--Conduct a northern California county training/orientation series.

* Provide information on what data products and services are currently available
* Introduce remote sensing, both photo interpretation and computer processing of remotely sensed data, as a new resource planning and management tool.
* Help counties define their information needs and determine the best mechanisms for meeting them.

INTRODUCTION

To best document the activities and accomplishments of the grant, I will restate the title and eight basic goals of the original proposal.

DEVELOPING AND DEMONSTRATING
AN INSTITUTIONAL MECHANISM FOR TRANSFERRING REMOTE SENSING
TECHNOLOGY TO 14 WESTERN STATES USING NORTHERN CALIFORNIA
AS THE TEST SITE

There is a strongly demonstrated and thoroughly documented need for an ideal institutional mechanism to bring about the successful and meaningful transfer of technology in the world today. It is an acknowledged fact by many experts dealing in the various aspects of this problem that no such mechanism exists. It is further acknowledged, and documented, that the technology of remote sensing is, and can be, a fitting, timely, cost-effective tool for inventory, assessment and monitoring of the natural resource base of the nation.

A powerful example exists in the findings of the Pacific Northwest Regional Commission's, Land Resources Inventory Demonstration Project of the states of Idaho, Oregon, and Washington. Through this, and other projects using remote sensing as an information gathering and analytical tool, it has been shown that this technology, when used in resource management and planning, can add significantly to the planning and decision-making process at Federal, state, and local levels.

This proposal, and its related activities, will provide, on a demonstration basis, a model for transfer of remote sensing technology and the model institutional mechanism for transfer in 14 western states of the United States.

The eight basic goals of the proposal are

1. To interact with the Pacific Northwest Regional Commission's Land Resources Inventory Project, to make direct use of their expertise and findings.

2. To create, design, and implement a model for remote sensing technology transfer using a small test site in northern California for maximum efficiency, interaction between participants, and economy in both human energy and dollar costs.

3. To transfer and disseminate knowledge of the techniques and applications of remote sensing, as used in the test site, to 14 western states in the western region.

4. To transfer and disseminate information and findings regarding the transfer Model and its institutional mechanism to the 14 western states region, and nationally.

5. To establish and test a working communications model (between project participants, and between the project and the public at-large) within the 14 western states region, and nationally.

6. To establish an innovative and effective documentation system, and to test that system as used in the demonstration project, and in the 14 western states region.

7. To establish and document communication links from the project to decision makers, individually, to decision making bodies and processes at Federal, state, and local levels within the 14 western state region, and on a national basis, where appropriate, as to viability of use of remote sensing in the decision-making process regarding the natural resources.

8. To formulate a series of recommendations and guidelines with input from all participants in the demonstration project and that will incorporate all of the above items, and will also include such key elements as analyzing social implications and cost-effectiveness of the use of remote sensing as an information gathering and analytical tool in resource based problems of northern California.

The proposal, and its related activities, will practically address some specific resource based problems in the disciplines of Forestry, Ocean and Coastal lands, River basins, and selected land use. In the Inter-cooperative project, National Aeronautics and Space Administration (NASA) personnel will participate with selected Federal, state, and local agency personnel; Humboldt State University professors, schools, and departments, The Center for Community Development; and, a Citizens Task Force and study group. The testing site will be physically located in northern California in a demonstration area that has several overlapping problems and projects already in existence, and will provide the ideal testing situation to achieve the goals of the proposal.

Coordination, documentation, dissemination, and communications regarding this test and demonstration site will be provided at the Center for Community Development, Humboldt State University, under the direction of the principal investigator, Donna B. Hankins, assisted by support staff and Dr. Lawrence Fox, Humboldt State University Forestry and remote sensing instructor. NASA will provide basic technical support (e.g., data needed by project participants, imagery, image processing, orientation programs, and so on) and training of project participants in the basics of remote sensing and techniques of application of the technology to the problems at hand. NASA will also provide valuable assistance and cooperation in the form of coordination, documentation, dissemination and communications from the local test site, to the western 14 state region.

These latter activities will take place at a facility near Ames Research Center, Moffett Field, California, which will provide for the training and coordination activities by use of a team of individuals selected especially for their demonstrated capabilities in the fields of remote sensing technology, communications, education, administration, and research. The entire multi-disciplinary team will interact either at Humboldt State University or at NASA Ames Research Center, or in the 14 western states region, as necessary.

The length of the demonstration project is expected to be approximately 3 years, with a start date of June 1, 1977, and an ending date of May 31, 1980.

Second, from the "Introduction" section of the orignal grant proposal, I will restate the portions which:

--Outline the <u>need</u> for developing an institutional mechanism for transfer of aerospace technology, and

--State the major <u>barriers</u> to developing and implementing such an institutional mechanism.

There exists at present no institutional mechanism that permits the large body of potential users--existing in federal agencies and in state and local governments, in industry and the business community, and in educational institutions--to express their needs and to have a voice in matters leading to the definition of new systems. To date, it is the providers of space systems and information who devise what they believe are useful requirements and proceed to build experimental systems. They then find themselves in the position of trying to "sell" this technology to prospective users. While this process works well (and needs to be continued) for stimulating technology, it needs to be reversed with regard to involvement of the users. There is then a perceived need for some institutional mechanism designed to assure participation in defining new applications.

The institutional problems are ones of organization, communication and leadership--problems which can only be ameliorated by establishing some means in addition to those which the Nation has developed to date for dealing with space technology. Such a mechanism (or mechanisms) is required to serve the following functions:

A. Provide general policy direction
B. Set priorities
C. Provide for communication between users and providers
D. Encourage non-federal involvement and investment

To facilitate these functions, the utilization, with their fullest consent possible, of the services, personnel, equipment, facilities, and information (including statistical information) of public and private agencies and organizations, and individuals, in order to avoid duplication of effort and expense, will be a necessary component. This utilization will also provide the necessary building blocks to identify and define the civilian problems at state, regional, and local levels which science, engineering, and technology may assist in resolving and/or ameliorating. As a necessary component, these "building blocks" will identify and foster ways to facilitate the transfer and utilization of research and development results to maximize their application to civilian-user needs. Concommitantly, it will result in improved methods for effecting transfer, innovation, and use of technology by users, and, by stimulating an effective liason between Federal, state, and local agencies, and industry and private user groups.

However, to achieve all of the fundamental and necessary components mentioned above, it is well to recognize the barriers to the development of an institutional mechanism. If these barriers are recognized and dealt with in a positive manner, their potential for causing the failure of an institutional mechanism will be eliminated.

The major barriers are:

1. Lack of awareness on the part of the public at-large, the business community, state and local agencies to utilization of NASA and space technology--inertia barrier.

2. Too many federal agencies trying to transfer technology to the private sector with no formal policies.

3. Federal agencies not equipped to directly transfer technology--non-existent transfer mechanism.

4. No organized effort on the part of agencies who develop the technology to market or transfer it to others--non-existent transfer management and organizational structure.

5. Communication barrier.

6. Limiting budgetary constraints on NASA's transfer program as well as other agencies--cost barrier.

7 Time and geographic distance barrier.

8. Reluctance on the part of industry to take the risks involved with developing the necessary products to disseminate the technology.

All of the above barriers should be addressed initially in any program designed to transfer technology. Dr. Hans Mark, past Director of NASA Ames Research Center, has stated the following:

> The least successful way of "transferring technology from one purpose to another is to have the federal government do it directly....This is principally a result of the people within the federal government not having the necessary skills to effect the transfer. Successful transfer requires that a market for the technological product be available,...is adapted well enough to that market so that accurate cost projections can be made, that...risk capital be accumulated, and that the special organization be created to carry the new product successfully to the market-place."

As to the role of the federal government in facilitating this process:

> "The process of technology transfer is an important one that must be nurtured and encouraged. It is strongly recommended that, in view of our experience in this field, proper incentives be provided for private industry and for individual technical people to encourage the transfer of appropriate technology to commercial markets as soon as feasible. In addition, it is important that the Federal Government, in undertaking a technology development program, understand thoroughly which part of the development is best done by private industry and which part is best accomplished under federal direction."

Mrs. Sally Bay, of the Task Force on Technology of the National Council of State Legislatures in its 1977 report to the Council, stated:

> "...the task force strongly emphasizes that the satellite technology may not be transferred to the state and local governments--due to flaws in the transfer process, rather than in the technology itself."

Thus, the problems and barriers are present, but can be eliminated. This proposal will deal in a real way with the problems from the very beginning.

The "model" being proposed will gather together all the elements necessary to bring about complete coordination between those who do the technical application, and those who will disseminate and publicize the results. In this way, the institutional mechanism will not only be developed, but will be in operation from the start. It will coalesce into a standard operating mechanism that will, with changes relevant to each region, facilitate the transfer of the technology, and, insure that the model is applicable to other areas as well.

In designing a comprehensive technology transfer program for our model region, careful consideration was given to the major potential transferring elements of this program. In other words, what are the unique features of the region that will aid or facilitate transfer?

In Northern California (here described as Humboldt, Del Norte, Mendocino, Siskiyou, Shasta, Modoc and Lassen Counties), Humboldt State University and several community colleges were identified as prime factors for technology transfer. The two key places within the university and community colleges where technology transfer can be facilitated are:

> STUDENT BODY - University training in remote sensing in a multi-disciplinary, well integrated program provides a core group of trained and knowledgeable people that will more readily utilize the technology as they go into their various discipline fields to work. At Humboldt State University, over 2,000 persons are enrolled as Natural Resource majors. By integrating remote sensing technology into a wide range of curriculum areas at Humboldt State, the technology users of the <u>near</u> future are created. Furthermore, this is an enhancement to the current offerings of the university, and should create new FTE dollares for the schools as more students become aware of the opportunity to add a valuable new skill to their regular discipline field.

> ACADEMIC FACULTY/STAFF - By training of selected university professors in remote sensing technology, integration of the technology into various curriculum areas can more quickly and easily take place. Furthermore, this training helps create a core group of trained discipline scientists who can assist in teaching and training those community and agency personnel involved in projects using the technology. Finally, new research in various discipline areas will take place after such training, providing enrichment and personal development for academic persons.

The report which follows documents the work of 1977-78 within the university community.

I. HSU Student Involvement

A. Remote Sensing of the Environment. In conjunction with Continuing Education, the NASA grant, Schools of Forestry, Science, Natural Resources, Winter Quarter 1978, an introductory course on remote sensing was offered. The course, designed to provide an overview of the theory and applications of the technology, had a concurrent enrollment of 80 University students and 22 Continuing Education students. In an attempt to provide wide coverage of the applications of the technology, the grant provided the following speakers:

1. Nancy Grabinski-Young· Tacoma, Washington, Urban Project, Applications in Land Use and Urban Analysis.

2. James Jeske: NASA Computer Applications Specialist; Applications for Automated Image Interpretation.

3. Dr. Floyd Sabins: Research Scientist for Chevron Corporation; Applications in Geology, Soils, Mineral Resources.

4. Ernest Daghir: National Environmental Satellite Service; Applications in Climatology, Hydrology, Environmental Monitoring.

5. Dr. Robert Hodgson: Humboldt State University; Applications in Oceanography.

6. Alan Snell: COMARC, Inc., Applications for Social Impact and Technology Assessment.

This course was repeated as a regular University offering during Spring Quarter 1978 at Humboldt State. (See Appendix I.)

B. In an effort to provide students with information and resources on remote sensing, the Project office has compiled a listing of students wanting to become involved. This listing can be broken down as follows:

1. Volunteers: Those interested in offering free time and unpaid energy (15 students).

2. Class Units: Those interested in gaining units under 199 Study Series, Independent Research, Field Classes, etc. (23 students).

3. Part-Time/Full-Time Employment· (12 students).

4. Graduate Level Research: Interested in applications of remote sensing to graduate research (15 students).

Also, student requests for information that can be used for class presentations of remote sensing applications (38 students).

NOTE: Three students in particular have been using remote sensing materials to define class projects that will lead to graduate level study.

C. During Spring Quarter, March 27 - June 10, 1978, a student intern worked directly with the Project office to survey existing legislation regarding remote sensing technology. It is hoped that a state-level intern program will be developed from this research.

D. Career Development. The Project in conjunction with the Career Development Center at HSU, held a one-day workshop on "Careers in Remote Sensing." A brochure developed for the workshop has begun distribution throughout 14 western states to colleges and universities. It is hoped that other programs between Career Development and the Project will include conferences, workshops and seminars to provide students with new ideas for future employment.

E. Throughout the past academic year, Donna Hankins, Joe Webster, Dr. Lawrence Fox, and Kamila Plesmid have made numerous presentations to classes and organizations on campus. This effort is viewed by the Project as a necessary responsibility to keep students and faculty fully informed and aware of remote sensing technology.

F. At the present time, two Graduate students, one in Forestry and one in Natural Resources, are currently working with the grant on demonstration projects. Ken Mayer, graduate in Natural Resources, is working in cooperation with the Project and the U.S. Fish and Wildlife Service on an investigation of the Hoopa Square. Jeff Soto, graduate in Forestry, is doing thesis work related to an overall vegetation cover classification on the Hoopa Square. Other activities of these two students include: Mayer providing lab assistance to Dr. Fox in the remote sensing course, and Soto doing training in photo-interpretation and mapping with Indian groups on the Klamath River, both students are gaining valuable training in the use of computer processing of Landsat data on-site at HSU and at NASA Ames Research Center

II. HSU Faculty Involvement

A. On December 3, 1977 and January 7, 1978, workshops were given to provide faculty and staff with information on remote sensing technology. Forty-eight members of the faculty attended these workshops and from them a series of action items were developed. From the action items, a steering group, headed by Drs. Fox and Hodgson, have developed a proposal for summer training at NASA Ames Research Center. This advanced training is intended to provide Humboldt State with a core group of professors well-versed in the technology and represent a multi-disciplinary group of concerned faculty members. It is hoped that through this training the integration of remote sensing programs into existing curriculum offerings can be accomplished.

B. Through arrangements and contacts at NASA Ames Research Center (ARC) and in consultation with Dr. Joseph Leeper, a sabbatical for Dr. Leeper to be spent at Ames has been given full approval (from NASA Ames). We would hope that these types of arrangements, at various times, could be provided other professors in the future.

C. Drs. Lawrence Fox (Forestry) and Robert Hodgson (Oceanography) during the past summer were able to get further training in the use of remote sensing and computer processing of the data. Through this training, it is felt that the University has been able to increase faculty awareness of the potentials of remote sensing technology. Also, Dr. Hodgson was able to gain valuable knowledge concerning the current "State of the Art" in remote sensing around the United States. His input and documentation has led to a broader outlook on the part of NASA Ames as to what changes are necessary vis-a-vis the dissemination of the technology. (See Appendix II.)

   Dr. Fox has continued his association with the grant through a consultancy arrangement. His valuable input on technical matters has been instrumental in providing for coordination and development of the existing demonstration projects. This will benefit Humboldt State by having at least one professor who is cognizant of the full use and applicability of remote sensing technology. Dr. Fox will be employed by the Project throughout the upcoming summer to provide continuity to new projects and planning for the future. Also, he will be involved with insuring that the summer program for professors is carried out effectively.

D. Various professors on campus have consulted with the Project on the possiblity of gaining support for research proposals that may or may not be applicable to remote sensing. At present, these proposals are being reveiwed by many individuals in the NASA system. We are hopeful that these proposals will be funded.

E. After consultation with representatives of HSU's Computer Center, we feel positive about the integration of Landsat data processing into the current system. There are, however, some very real problems. Much of the existing equipment would need to be added to for full capability. Also, storage and retrieval capacity would need updating, as well as the possible increase in manpower to work with such a program.

One of the unique features of any region that will facilitate transfer of technology is the web of the "community." An informed and aware community can assist technology transfer by influencing decision makers and by passing needed legislation. We have defined this "community" to encompass the general, lay public, local and regional; agencies or potential/actual user groups, local and regional; major industries and decision and policy makers. Thus, our definition includes a "community" which reaches from right outside the window to Washington, D.C. In Northern California, this community is extremely diverse, if sparse. Here, the Natural Resource is the direct economic base. The general lay public is employed by or closely connected to the major industries which extract the Natural Resources. Furthermore, the agencies work with, monitor, control or assist extraction of the same resources and the regional decision and policy makers are usually keenly aware of the problems of the resources, their allocations, etc. Hence, any "tool" which even promises better and more cost-effective inventory, assessment and monitoring of the same resource base is guaranteed to at least receive modest attention.

So, the first stage of our approach in Northern California has been to essentially "scan" the local market and decide upon several communication modes best designed to inform about and increase awareness of the technology in the community as defined. Furthermore, assessment of all California was judged a necessary task, to, again, determine what the potential market might be for this technology in a state which has encountered numerous past problems in getting involved. (No assessment has yet been made of the projects and actual user groups of the WRAP area to determine the entire potential market for the technology in 14 western states.)

Communication models are being currently assessed, after one year of work, for identification of those elements which need further attention.

The following report details the major efforts made by the project in informing and involving the "community," as defined above.

III. Community Involvement. As part of the overall tasks and responsibilities of the grant, extensive community awareness has begun This community program has been viewed as an integral part of any technology transfer effort. (See Appendix III.)

A. Community presentations - Project staff have made over 50 presentations to business (e.g., Lions, Kiwanis, Rotary) and civic groups to stimulate awareness in the community. The response from these groups has been favorable and has led to many important viewpoints being given expression. These presentation are expected to continue.

1. Business and Industry: 286 people

2. Decision-makers: 167 people

3. General Educational: 634 people

B. Signature - The project is currently publishing a newsletter which is being sent to most of the fifty states and a few foreign countries. The content of the newsletter provides a synopsis of activities in the Northern California area; information on legislative programs, conferences/workshops; and, images of key personnel involved in technology transfer. Under the editorship of Ms. Kamila Plesmid, this newsletter is now being expanded to cover the entire 14 western state WRAP (Western Regional Applications Program) service area. (See Appendix IV.)

C. American Indian Tele-communications Satellite Demonstration Project - Throughout the United States, a large percentage of landholdings are held by various Indian Tribal groups. As they have recently been given the right to develop their own lands, information and training as to the best possible ways to achieve this task has become important. The "tele-communications project" is a demonstration in attempting a new method of education and information dissemination.

The grant, in cooperation with Mr. Jerry Elliot of Johnson Space Center, Houston, has been given two major tasks for this project. First, to develop a video-tape that will show the technology transfer/education program currently in operation in Northern California. Second, to provide expertise in evaluation of the effects of this overall program in its first attempt.

The video-tape program (20 minutes) will provide background to the grant, its activities concerning technology transfer, and its efforts on behalf of the Indian community on the Hoopa Reservation and extension. The evaluation scheme is to provide for input into the effectiveness of this type of program development throughout the United States. This program was initiated in early April, 1978.

D. Documentary Film - The grant has been involved with a documentary program that is intended to provide visual documentation of its activities. This film, in progress at this time, will cover the interactions of the grant personnel in dealing with day-to-day problems, and development of the technology transfer mechanism. This film will also be used to explain how technology transfer can work, who were the participants/actors in the process, and how others can become involved. (Not finished - too costly. Film was incorporated into videotape, Part C, above.)

E. Simulation Activity - In reacting with members of the community-at-large, grant personnel have been developing a "simulation activity." This simulation is intended to 1) establish a level of awareness for the technology, 2) show how the information is needed, and 3) improve the awareness of how the techonology can be integrated into traditional information gathering needs. Ms. Marion Dresner, graduate student in Natural Resources, HSU, has been instrumental in providing the framework within which the activity is to take place. The simulation has been used in a trial session with a group from the community. From that session, we will refine the activity into a format that can be applied in other areas and with other groups.

SUMMARY -- The community awareness program of the grant is quite extensive. It involves not only Northern California, but the full 14 western state region. The grant personnel believe that this program will be an ever expanding process and are taking the necessary steps to insure its completion.

IV. Training activities. A major component of grant activities has been to develop "training" programs that assist the transfer of technology to users. Each of the following training sessions followed a basic format of instruction:

1. Introduction to the technology - remote sensing theory.
2. Applications of the technology - applied remote sensing.
3. Exercises designed to provide use of remote sensing data.
4. Follow-up activities to provide better techniques for training programs.

As more potential users become familiar with the technology, these training programs will increase. Following is a list of training programs completed as of May 31, 1978.

Each program was designed to give each participant knowledge of the technology as it related to the specific agency. (See Appendix II.)

A. State Agencies 135 people

B Federal Agencies 126 people

C Local Agencies· 179 people

D. University/Faculty: 173 people

V. California Activities. As the grant is intended to pursue its goals as a model to be applied throughout 14 western states, it is necessary to develop the model in that context. To do so implies gaining information concerning those areas. The following is a summary of the activities regarding the State of California.

A. Demonstration Projects - The technical demonstrations of the use of the technology have been the hardest program areas to be initiated. Part of the problem has been the lack of trained personnel to take part in this activity. However, if the program here at HSU is to be effective, this element must be increased. Working with the technologists at NASA Ames, the project personnel are now in a position to finalize and place more emphasis on this segment of the program. The technical know-how and coordination will be tightened and "brought-up-to-speed" to insure adequate technical development and use.

At present, there are three demonstration projects in progress: 1) U.S. Fish and Wildlife Service study of the Trinity River watershed on the Hoopa Square; 2) Hoopa Square overall vegetation cover classification graduate research project, HSU; 3) Klamath River, basic photo-interpretation/mapping program for U.S. Census Bureau and Indians on the Klamath River. These three programs are underway and the participants (Ken Mayer and Jeff Soto) are working in conjunction with the agencies and individual groups concerned. (See Appendix V.)

Along with the three projects mentioned above, the following is a list of proposed projects that are currently under negotiation.

1. Trinity River Task Force: Trinity River Basin in Northern California; 11 agencies (federal, state, local) involved.

2. Six County Regional Proposal: six counties in Northern California possible joint powers proposal.

3. California Parks and Recreation: Redding, California region.

4. Archaeological/cultural Resource Consortium: Northwest California, proposal to utilize remote sensing techniques investigating cultural and archaeological sites. These projects not attempted due to time and funding restraints.)

B. Californa State Survey of Remote Sensing Activities - In many ways the project has found that very little information has been shared concerning the use of remote sensing technology. A survey has begun on developing a compendium on these activities. Its goal is to provide anyone interested with a list of projects going on in universities, state colleges, federal and state agencies, county departments and industry. This survey will be forwarded to NASA Ames and the Governor's office as soon as complete (expected completion -- end of June, 1978). This will be the first time that such information will be available and represents seven months of constant involvement and compilation. (See Appendix VI.)

C. Proposed California Task Force - The Project has assisted in developing a proposal for a State of California remote sensing task force. The purpose of the group will be to coordinate all activities in the State of California using remote sensing technology. As a beginning step, assisted in charter meeting of the California Remote Sensing Advisory Council (CRSAC) representing agency persons utilizing or wishing to use remote sensing in their activities. The CRSAC is viewed as a foundation for coordination between state, university, and industrial groups wishing to form State Task Force. (See Appendix VII.)

SUMMARY -- The activities in California are intended as initial steps in providing for long-range planning for the use of remote sensing. The "Survey" and activities of the demonstration projects are viewed as focal points for future expanded use of the technology.

VI. Western Regional Applications Program (WRAP). As part of the grant's goals and objectives, we are to provide a "test-site" for ideas and actions, and become a "model" for WRAP objectives in 14 western states. The project staff at Ames has been moving on all fronts in an attempt to generate interest and ideas/actions throughout this area. The following are highlights of that program: (See also Appendix VIII.)

A. Centralizing State Interests - The team at NASA Ames has been in contact with individuals within each of the 14 western states. These groups represent legislators, top-level agency heads, universities and industrial concerns. Many of these groups have centralized their contact through one or more individuals who will act at focal points for communication and activities. Specifically, these focal point individuals and groups will provide coordination between their states activities and those of WRAP. Using the experiences gained through the Northern California test-site, each state will have a coordinated and inter-cooperative team to define project activities. A network for communication dissemination will then be firmly established throughout the region.

B. University and College Survey - As the Humboldt State Project office is surveying remote sensing activities in California, the WRAP program is surveying universities and colleges throughout their service area. Specifically, each university and college will be quizzed on 1) their existing (or non-existing) programs in remote sensing, 2) their level of course work and/or knowledge of remote sensing, and 3) if they are going to become involved with, or expand the programs in, remote sensing.

C. State Programs in WRAP

1. Arizona: Through ARIS (Arizona Resource Information System), a data base for the state, WRAP is helping to define a series of projects with the Jet Propulsion Laboratory, Pasadena. This support is now in its final state. One example of how this is working is the legislative proposal to move ARIS into the Arizona State Department of Lands. In doing so, increased data needs and services will help expand the program.

2. Colorado: The Colorado State Mapping Advisory Committee has been appointed as the focal point for remote sensing activities. Negotiations are now in progress to set-up a joint presentation between WRAP and State offices in the use and capabilities of remote sensing.

3. Hawaii: In November, 1977, seven individuals representing various resource agencies attended a two-week training program. Sponsored by the grant, NASA Ames and in cooperation with U.C. Berkeley, the theory and application of remote sensing was explained and hands-on training provided. From that session, State agency heads have been designated as a Task Force to coordinate any remote sensing programs. This group, in cooperation with WRAP Program leaders, is now attempting to define a project proposal plan.

4. Montana, A series of orientation and brief training sessions at NASA Ames and in Helena have been accomplished by the WRAP team. The state has developed 13 demonstration project proposals which are now being evaluated. Plans are now in operation to attempt one major land use project with others to be added later. In late April, agency representatives from Montana participated in further training.

5. Other States: The WRAP team is currently in negotiations with other states in the region. From these negotiations, training and project planning will occur and increased activity is expected. By identifying a focal point in each state, the WRAP team will be better able to coordinate overall planning with each state, as well as develop dialog and communication links.

D. Summary Reports to NASA Headquarters - Ms. Phoebe Williams, Director of User Awareness at Ames, has been developing a series of monthly activity reports. These reports go directly to NASA Headquarters in Washington, D.C. on all activities of the WRAP.

E. Conference of Remote Sensing Educators (CORSE) - In June, 1978, the grant, WRAP, USGS, and others will hold a conference for educators in remote sensing. The main goal is to "promote the teaching of remote sensing at universities, colleges, and other academic institutions."

F. National Council of State Legislators (NCSL) - Tahoe Conference - As an on-going program of coordination between WRAP and its service area, WRAP and NCSL co-sponsored a conference at Tahoe on remote sensing. Various representatives of WRAP outlined the objectives and goals of their program and explained the need for legislative support.

G. MATE (Mobile Analysis and Tele-communications Experiment) - MATE will give state people a chance to find out whether they can use remote display terminals in different locations interacting with a Landsat image processsing computer in a central location. The WRAP team is supervising the use and deployment of the MATE throughout the 14 western state region.

SUMMARY -- All of the above are highlights of the WRAP program and the grant's personnel involvement in those activities. There are many others that are in progress and relate to one or more of the above. The WRAP program relies on the "model" activities developed in Northern California and incorporates those processes into their operations with other areas.

Goals and Objectives	Number of Activities
1. Interact with the Pacific Northwest Regional Commission's Land Resources Inventory Project.	11
2. Create, design, and implement a model for remote sensing technology transfer in Northern California.	26
3. Transfer and disseminate knowledge of techniques and applications of remote sensing.	16
4. Transfer and disseminate information and findings to the 14 western states region, and nationally	26
5. Establish and test a working communications model within the 14 western states region, and nationally.	22
6. Establish an innovative and effective documentation system and test that system as used in the demonstration project, and in the 14 western states region.	13
7. Establish and document communication links from the project to decision makers, individually to decision making bodies and processes at federal, state and local levels.	13
8. Formulate a series of recommendations and guidelines to incorporate all of above items and include other key elements for analyzing implications of the use of remote sensing as an information gathering and analytical tool.	26

Activity	Goals and Objectives 1	2	3	4	5	6	7	8	Barriers Addressed 1	2	3	4	5	6	7	8	Participants Identified
I. Student Involvement--A	x	x		x				x	x		x	x			x	x	120
B	x	x	x	x	x			x	x		x	x	x	x	x		65
C		x		x			x	x	x	x	x	x	x	x			1
D		x	x	x	x	x		x	x		x	x	x	x	x		30
E		x		x	x			x	x		x	x	x	x			300
F	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	2
II. Faculty Involvement--A		x	x	x	x	x		x	x		x	x	x	x	x		52
B	x	x	x	x	x	x		x			x	x	x	x	x		1
C	x	x	x	x	x	x		x	x		x	x	x	x	x		2
D		x	x	x	x			x	x								12
E		x		x				x	x					x	x		-0-
III. Community Involvement-A-1*		x		x	x			x	x		x		x	x	x	x	286
A-2*		x		x	x		x	x	x	x	x		x	x	x		167
A-3*		x	x	x	x			x	x		x		x	x	x		634
B	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1,900
C*		x	x	x	x	x	x	x	x	x	x	x	x	x	x		200
D*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
E		x		x	x			x	x		x		x	x	x		17
IV. Training Programs -- A*		x	x	x	x	x	x	x	x		x	x	x	x	x		135
B*		x	x	x	x	x	x	x	x	x	x	x	x	x	x		126
C*		x		x	x		x	x	x		x	x	x	x	x		179
D*	x	x		x	x			x	x		x	x	x	x	x		173
V California Activities - A*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Unavailable
B*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	"
C		x		x			x	x	x	x	x	x	x	x	x	x	"
VI. WRAP Program *	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Unavailable
TOTAL	11	26	16	26	22	13	13	26	25	11	24	20	23	24	23	9	4,417

* Activities which were instrumental in identifying and formulating conclusions discussed in the summary/conclusion of this report.

TECHNICAL SUMMARY

NOTE: A full technical review will be completed after September 31, 1978. This summary represents a brief overview of major technical accomplishments to date.

The Project staff has advanced a greater understanding of remote sensing technology along two major fronts: the university and the community. There has been a positive effect on Humboldt State University students and teachers. The 120 students taking the class, "Remote Sensing of the Environment," have been exposed to the influence of working professionals in remote sensing through the grant's visiting lecturer program. This has enabled them to see the relative advantages of enhancement vs. digital analysis techniques, high altitude aircraft vs. Landsat, thermal vs. reflective techniques and many other methods. The illustrations and case studies brought forth by these individuals have provided a unique learning experience for the students. About thirty students have also had the opportunity to view the computer terminal hook-up to Ames in a live demonstration of unsupervised classification techniques. This should repeat each time the class is offered (scheduled for twice per year).

Of course, many more students have been at least exposed to remote sensing These have begun to realize the difference between Landsat digital and color-IR photographs as they have viewed the library displays acquired by the grant staff. A few students (8 to 10) have become more deeply involved in graduate studies using remote sensing. They have been helped tremendously by counseling with the grant staff about every aspect of remote sensing from ordering data from EROS to discriminating spectral classes using Landsat.

All of the faculty have been at least influenced by the grant activity and understand a little more about remote sensing. Nine instructors have or will shortly receive further training. Remote sensing has and will be presented as a useful tool to be used in a fully integrated approach to resource inventory. These faculty understand how Landsat may help in overall stratification, or primary sampling unit description. They know how the U2 and low altitude aircraft also fit into the picture as sampling tools for maximum cost efficiency. They have and will also learn the basics of Landsat digital analysis, contrast stretching, supervised and unsupervised classification techniques, digitized summary strata and various output products. By the end of this summer, these faculty members will be able to intelligently include remote sensing as a useful inventory tool in their courses and professional activities.

The emphasis on further remote sensing education at Humboldt State will stress integration of remote sensing as an inventory tool. A new course in inventory design may be taught in the School of Natural Resources. This class would stress remote sensing techniques from aerial sketch mapping to Landsat digital analysis showing the most beneficial application of each or all in a multi-level approach This is one of the ideas proposed by the Natural Resources Curriculum Committee.

The major technical effort in the community is the U.S. Fish and Wildlife Service Demonstration Project on the Hoopa Indian Reservation. Ken Mayer and Jeff Soto (a cooperating graduate student) have received extensive training in Landsat data analysis applied to vegetation mapping. The approach was initially unsupervised using the ARPANET/Editor system to classify a portion of a Landsat scene into 20 spectrally distinct categories. Using LP maps, dicomed color coded prints and U2 photography, these two men have evaluated the classification. They are now using supervised techniques and guided clustering to establish valid statistics for the information classes they need. It is through this often painful and frustrating process that most of the truly technical expertise is being learned. A final session at Ames will take place in the near future to evaluate all of the statistics generated and arrive at a final classification. Most importantly, the day-to-day work on resource category description is being done by remote terminal at Humboldt State University, providing a level of independence from Ames never before realized.

Gary Rankel (Ken's supervisor and a fisheries biologist with the U.S. Fish and Wildlife Service) has been kept up to date on all phases of the project. He has seen the raw data, partially classified data, and will be thoroughly briefed on the final product. Because he has been involved from the beginning, he will understand the final map thoroughly and be in an excellent position to explain the benefits of satellite remote sensing to his co-workers and supervisors. Of particular technical importance is the relationship of this project to the overall project of the Trinity River Task Force.

Several other working professionals in the U.S. Forest Service, California Department of Forestry, California Department of Water Resources, and many other agencies have been given a technical orientation to the technology. Through specialized workshops and training sessions, the staff at Humboldt State University has helped these people understand the most efficient use of the various remote sensing platforms available. Most importantly, they have seen Landsat at full resolution (say 1 50,000) in combination with standard topographic maps. This kind of approach will help them see high altitude remote sensing in its proper light. It is a system to be integrated with other techniques but also will stand alone in the ability to display resource categories in a clear way with sufficient working space (large enough scale) on the final product to make it a tool and not a wall decoration.

The overall technical achievements have been impressive. The Humboldt State University effort is only limited by full time technical coordination. It is considered that with the addition of both the Bendix MDAS equipment and by activating use of Humboldt State computers (part of CSUC Computer system) to process Landsat digital data as part of academic/instructional program, that full time technical coordination will automatically come about.

This is a major problem that will be addressed as part of the technology transfer to the university during fiscal year 1979.

CONCLUSIONS

Several practical and useful conclusions have been drawn from analysis of the last year's activities. These conclusions have been prepared from Project staff examination and evaluation of nearly 2,000 pages of notes; evaluations of countless workshops and presentations and the priceless input of hundreds of community members, agency personnel and friends of the "space" group.

It is clear to all involved in the Northern California project that whereas much work needs to be finalized and supported by NASA in the next year, that practically, we are truly heading towards the goal set several years ago. That goal is a regional appropriate technology center, which will work with a variety of technologies, some coming from NASA, some from other areas.

We have utilized our technology transfer model building efforts to the fullest extent and can demonstrate the next steps that must be taken. The following conclusions will form the background and basis for our fiscal year 1979 proposal, which should, at its conclusion, end NASA support and see the region launched into an appropriate operational status.

The major conclusions are as follows·

--There is a resistance factor in most all agencies to accept a change from traditional methods of data acquisition, reduction and analysis. This resistance factor may well be overcome slowly and gradually by building confidence in the new technology. The gradual change must be facilitated by multiple exposures to the new technological tools, and by a regional advocate known to and trusted by the users.

--There is an "upside-down" syndrome being developed by NASA's natural eagerness and enthusiasm to "sell" Landsat technology. Lip service is being given to the need for integration of the satellite data with conventional data and tools, but no real up-front effort has been made by NASA to make sure users are aware of what else is available. This appears to be a serious oversight, since familiarity with what other conventional tools (such as the wide variety of USGS-Geography, GIRAS, LIA program materials) most often has lead (in our experience) to a greater understanding of how Landsat data can work for them. The idea is to help users get the right tool to fit the task at hand.

--There is a strong need for local or regional "arms" of the NASA ARC involved in the WRAP. Most state and local agency personnel are so busy and travel budgets so short, that the needed multiple extensive training courses, often tedious human interaction with computer, calculator and light table, cannot take place as they should. This results in projects being shortcut, abandoned or poorly done. Day to day liason must be performed on a local basis to insure good results and hence, real technology transfer.

Furthermore, NASA ARC cannot respond to small localized projects due to distance from such projects, time and lack of people resources to respond. A localized "arm" of NASA ARC, such as the Northern California Project team, can easily respond to such localized needs, and at nominal cost.

--Users or potential users have a strong need to know that their problems and projects can be approached in a timely fashion. Dependence upon the uncertain or limited resources currently available within NASA ARC has led to uncertainty and confusion within various agencies desiring to get involved. Furthermore, numerous entities in the Northern California region are not really interested in demonstration projects per se. They are interested in doing actual projects in a semi-operational mode and simply need help to get started. A local or regional arm for NASA ARC, by providing support to numerous small but semi-operational projects and relying on regional resources, will insure real integration of the technology into operational programs.

In the near future, this type of "arm" can transcend into a permanent technology assistance center, which would be totally funded from sources other than NASA.

--There is a strong need to be sure that the projects and programs under WRAP or RAP, in general, truly fit the locality or agency from which they arise. Certain of these projects may cover only small land areas, but will provide important individual components of a regional data base. This "data base" concept needs to be carefully developed and must be brought to the users attention early in the game.

--There is a powerful need to train and educate the "legislation-forming" strata in state and local government, regarding the use and application of remotely sensed data. This "strata" may not, in fact, be the legislators themselves, but legislative aids, research analysts, interns, etc. The strata must be more clearly defined and an organized attempt made to set up training workshops and initiate information flows to all within this strata. At present, there appear to be no recommendations or stipulations to use specific tools in implementing work plans attached to legislation that affect natural resources, as a result of lack of information at the "legislation formation" level.

--There is a strong need for information and education about uses and applications of remotely sensed data to be extended to all American Indian tribes. American Indians own a startlingly large percentage of the total land mass of the United States. Recent trends indicate that, more and more, Indians will resume control and management of their own lands. By the nature of the changing role of these citizens and their often remote locations, they are prevented from knowing about or using even conventional and traditional resource management tools. Therefore, the needed education and information should include several sections on the nature of resource management, conventional management tools and resource data collection, as well as sections on remotely sensed data collection and appreciation.

--A most critical need is the early resolution of the "experimental Landsat" problem. It is difficult to honestly tell users they are absolutely assured of getting satellite data for extended periods of time. Often, the repeatibility component, along with well documented and archived satellite data records is the single most attractive feature to potential users.

In attempting to determine the status of this difficult theme, it was observed that certain critically needed and very basic background information does not exist that decision makers could plug into their deliberations. Among the basic information needs is a detailed survey of what actual data users there are, how the data is being used, and what data collection needs to be repeated on a regular basis, either by federal, state or local legislation, or by practice. This survey should be on a state by state basis.

--There is a powerful need for NASA to encourage and assist development of a wide array of remote sensing technology transfer institutional mechanisms. Key among these is the transfer of a remote sensing capability to universities and community colleges so these institutions can begin assuming their role in training and educating students and community users. The traditional "research lab" must not be abandoned in the rush to "transfer technology," since much research remains to be done in on-coming satellite programs and systems. But certainly, there must be clear definition with and to the universities as to their role in research versus transfer of technology.

--There is a growing need to direct a major communication effort regarding the technology of remote sensing (and the possible peripheral "spin-offs" and related business opportunities and advances) to industries. These industries should not be those particularly of or closely related to aerospace, but small businesses and industries which deal with sale or distribution and development of land, natural resources, etc.

--There is a strong need for NASA to encourage and to take an active role in creating an interface between the would-be "user community" and the Remote Sensing private sector.

--There should be an evaluation made of the potential user community within county governments and entities.

APPENDIX I

Documentation: Examples of Student Involvement in Remote Sensing as a Result of Grant Activities

* "Remote Sensing of the Environment" Brochure, January 11 - March 15, 1978

* "Office of Continuing Education Extension Course Offerings," Winter 1978 Brochure

* List of Students Interested in Involvement with Remote Sensing

* "Remote Sensing of the Environment" Report by Dr. Lawrence Fox III

* "Remote Sensing in Latin America," Report by David Hughell

OFFICE OF CONTINUING EDUCATION
HUMBOLDT STATE UNIVERSITY
ARCATA, CA 95521

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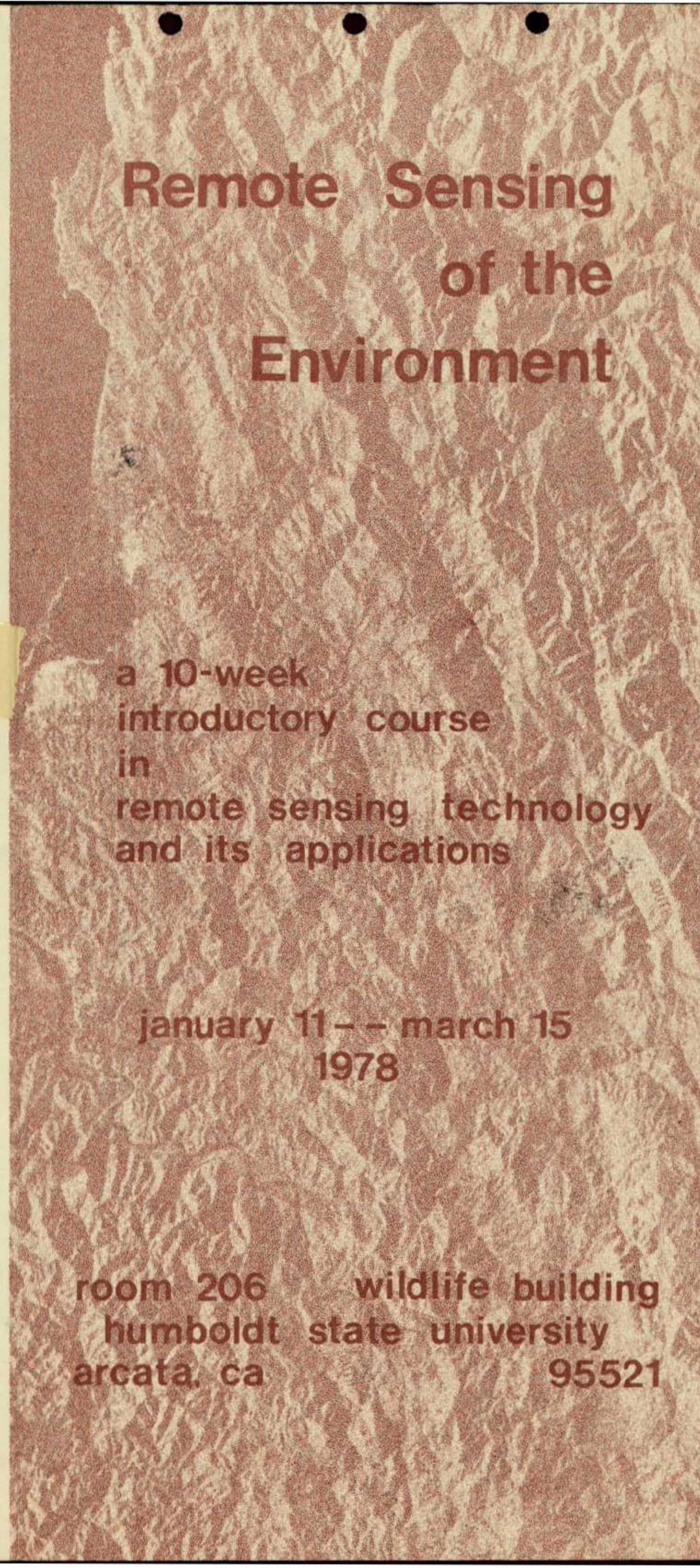


Remote Sensing of the Environment

a 10-week introductory course in remote sensing technology and its applications

january 11 - - march 15
1978

room 206 wildlife building
humboldt state university
arcata, ca 95521

Instructor Dr. Larry Fox examining initial computer printout from satellite data of Humboldt Bay

IN ST 106T REMOTE SENSING OF THE ENVIRONMENT

Today everyone seems to be feeling the information crunch. More information is needed, faster, and in greater detail than ever before, especially for resource management and planning. Remote sensing tools such as high altitude aerial photography and satellite imagery are adding significantly to the decision-making process at all levels of government and private industry.

"Remote Sensing of the Environment" is designed for both the student and the community member or agency person that is interested in understanding the practical applications of remote sensing technology. The course, offered through Humboldt State University's office of Continuing Education, will take a comprehensive look at the theory of remote sensing as well as its current and potential uses. More than half of the lecture time will be spent on applications in such fields as forestry, range, wildlife, and agriculture; land use and urban analysis; geology, soils, and minerals; and climatology, hydrology, and oceanography. It is the feeling of the instructor, Dr. Larry Fox, that when people are familiar with what remote sensing tools can and cannot do, they will be able to make intelligent decisions about their use.

The 10-week course, beginning January 11, 1978, will be held Wednesday evenings, from 6 to 8 p.m., in Room 206 Wildlife Building, Humboldt State University. The course can be taken for credit or non-credit with an optional 2-hour lab session.

REMOTE SENSING COURSE SCHEDULE

Week #	Date	Subject
1	Jan 11	Introduction Application Examples Possible Data Products Sources of Data
2	Jan 18	Electromagnetic Spectrum Kinds of Sensors Spectral Signatures
3	Jan 25	Sensor Platforms: Space & Aircraft Multi-Concept Image Interpretation Scale
4	Feb 1	Image Measurements Exam
5	Feb 8	Applications in Agriculture, Range, Wildlife Applications in Forestry
6	Feb 15	Application in Land-Use and Urban Analysis
7	Feb 22	Automated Image Interpretation
8	Mar 1	Applications in Geology, Soils, Mineral Resources
9	Mar 8	Applications in Climatology, Hydrology, Environmental Monitoring Applications in Oceanography
10	Mar 15	Social Impacts and Technology Assessment
		Final Exam

Lecturer	*Lab Topic*
Dr. Larry Fox, HSU	Photo Interpretation
Dr. Fox	Spectral Signature Exercise Field Photo Tour
Dr. Fox	Color Film Interpretation
Dr. Fox	Image Measurements
Dr. Robin Welch, NASA, WRAP Program	Natural Resource Mapping
Dr. Wayne Rohde, EROS, Data Center	
Nancy Grabinski-Young, Tacoma, Wash. Urban Project	Urban Interpretation
Dr. Jim Jeske, NASA Computer Applications Specialist	Automated Classification Exercise
Dr. Floyd Sabin, Chevron Corp.	Geologic Interpretation
NOAA Representative	Weather Interpretation
Dr. Robert Hodgson, HSU	Ocean Interpretation
Donna Hankins, NASA/HSU Grant Alan Snell, COMARC COMARC, Inc. Design Systems	Exam

NON-CREDIT: $20 REGISTRATION FEE
$10 LAB FEE

2-3 UNITS CREDIT: AN ADDITIONAL $10 PER UNIT

For further information contact:

Continuing Education
Humboldt State University
Arcata, CA 826-3711

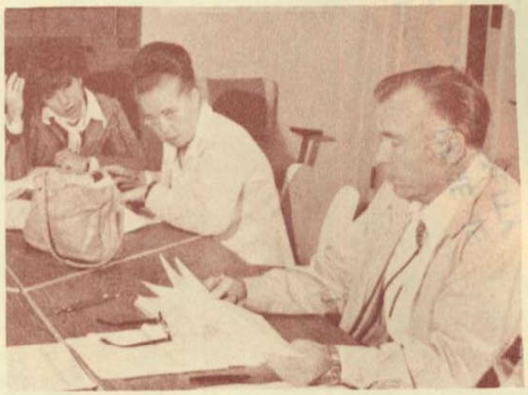
IN ST 107T REMOTE SENSING WORKSHOP (2 HOUR LAB)

Companion to the introductory remote sensing course is a 2-hour lab immediately following the Wednesday night lecture. The lab is an excellent opportunity for agency and community people to get "hands on" experience with the technology. Lab sessions will cover the basics of photo interpretation and natural resource mapping; automated classification of satellite data; and interpretation of urban, geologic, weather, and ocean features from satellite and photographic imagery.

GUEST LECTURERS IN REMOTE SENSING

A group of guest speakers, nationally known for their work on key remote sensing projects, add another dimension to the remote sensing course. Each speaker represents a different aspect of the technology's application, whether in federal agencies, large area demonstration projects, or private industry. Many of these authorities, such as Dr. Robin Welch, Director of User Training for the Western Regional Application Program (WRAP), are furnished through the NASA Remote Sensing grant, awarded to Humboldt State University in June, 1977.

Coordinating the lectures and the lab session is Dr. Larry Fox, lecturer in Forestry at Humboldt State and technical coordinator for the Remote Sensing grant. In that capacity, Dr. Fox works closely with the WRAP program and with participants in the northern California remote sensing demonstration project.



Dr. Robin Welch, WRAP remote sensing specialist with HSU grant people


Winter
1975
HUMBOLDT STATE UNIVERSITY
ΦΩΣ ΑΛΗΘΕΙΑ
Arcata, Ca. 95521
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Office of Continuing Education
Course
A NEW PERSPECTIVE...

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"REMOTE SENSING OF ENVIRONMENT"

Winter Quarter 1978

by

Lawrence Fox III

Report prepared for Donna Hankins,
Principal Investigator NSG-2244

INTRODUCTION

In January, 1977, an interdisciplinary course in remote sensing was offered at Humboldt State University. Over 100 students attended the class including 20 working professionals enrolled through Continuing Education. With this offering, remote sensing had become a permanent part of the University curriculum at an interdisciplinary level. Remote sensing was taught previously as a temporary course in the Geography Department.

The Northern California Technology Transfer Project (D. Hankins, Principal Investigator), through the NASA Ames Research Center, provided major support for the course in the form of several guest speakers and laboratory imagery. This paper is prepared to describe the course and document NASA's support and involvement.

COURSE OBJECTIVES AND OVERVIEW

The course is designed as an introduction to remote sensing technology and applications. The lecture portion is two quarter units and the optional workshop section or "lab" is one quarter unit. Students need not possess a background in Physics or higher Math to understand the course. An orientation to Geography or other earth sciences is a valuable asset for students in the class.

The first half of the class (six weeks) addresses the technology of remote sensing including simple devices (aerial cameras) and complex systems (synthetic aperature radars). During the second half of the course (four weeks), applications of remote sensing as an inventory tool are discussed. Earth Science disciplines, including Agriculture, Geography, Geology, Natural Resources Management, and Water Resources Management, are addressed with respect to inventory needs and application of remote sensing techniques.

LECTURE SUMMARY

The class met one evening a week for ten weeks. Two laboratory sections met during the day and one lab met after the lecture. The text for the course was: Eye in the Sky by Dorothy Harper, Multiscience Publications Ltd. 1976. 169 pgs. The subjects of each presentation and names of presentors are listed below; NASA provided all presenters which are starred. Having these guest lectures greatly increased student interest and provided class attendees with an opportunity to hear from people involved in a specific area of remote sensing. These discipline experts provided by NASA gave very complete and exciting presentations on the application of remote sensing in their field of study.

Session #	Subject	Presentor
1	Introduction - Complete review of remote sensing concepts illustrated with slides. Applications discussed within the framework of various remote sensing systems.	L. Fox
2	The Electromagnetic spectrum and how to utilize it for remote sensing. U.V., visible, reflected infrared, thermal infrared, and microwave radiation described in terms of frequency, wavelength and systems used to exploit each part of the spectrum.	L. Fox
3	The spectral signature and implications for multi-spectral remote sensing. Several illustrations of spectral signatures using color and color IR film. Expansion of the multi-concept in remote sensing; date, scale, sensor.	L. Fox
4	Platforms: space and aircraft. Resulting image characteristics, scale, resolution. Summary of the characteristics of conventional aircraft, U-2, and satellite (Landsat, Skylab) imagery.	L. Fox
5	Application in Agriculture, Range, and Wildlife Management. Examples of useful remote sensing techniques in: 1) Agricultural inventory (multi-temporal imagery, Landsat inventory - LACIE); 2) Range assessment (IR/red ratio as an indicator of biomass low altitude photography, etc.); 3) Wildlife Management, stressing habitat mapping.	L. Fox
6	A) Application in Forestry. Examples of airphoto interpretation in forest inventory, site analysis and timber management planning. Use of Landsat data for timber inventory and land-use planning. B) Applications in Land-Use Planning and urban studies. Landsat as a data base for regional urban studies and land use planning.	L. Fox N. Grabinski: Young * (City of Tacoma)
7	Computerized image analysis. Description of computerized data format, masks and other analysis techniques. Philosophy of image processing, supervised and unsupervised approaches.	J. Jeske * (NASA Ames Research Center)

Session #	Subject	Presentor
8	Application in Geology. Image enhancement techniques, band ratio, contrast stretching. Orbital plateforms for the regional perspective. Remote sensing as a first stage to mineral and oil exploration.	F. Sabins * (Chevron Oil Corp.)
9	A) Application in Climatology. Global weather patterns, geosynchronous satellite data.	E. Daeger * (NOAA, NESS)
	B) Application in Oceanography. Remote sensing to provide synoptic view of the vast amount of information needed. Data gathering by ship expensive and time co' suming.	R. Hodgson (Humboldt State)
10	Environmental Data Base Concept. Definition of a computerized data base, inputs (geology map, soils survey, remotely sensed information on land cover) and outputs (derived variable maps such as erosion potential, development suitability maps).	A. Snell * (COMARC)
	FINAL EXAM	

LABORATORY SUMMARY

The purpose in lab was to provide students practical experience in interpreting remote sensing imagery and to give them a chance to complete illustrative exercises using many of the concepts presented in lecture. The elements of image interpretation were introduced in the first lab using conventional color photography. Basics of stereo viewing were presented and practiced.

Lab two was devoted to an exercise in which the students were required to view low altitude panchromatic photos as a multi-spectral scanner would. Each student was able to see how a pixel grid is placed over the landscape and what digital numbers represent for various features. The process of evaluating a multi-spectral classification was covered in lab three. Scanner classes were compared to "truth" in a contingency table. Simulated multi-spectral scanner data was graphed to gain a greater understanding of the concept of "spectral signature."

Lab four was used for image interpretation (U-2, color-IR photography). Landscape characteristics and features were pointed out and discussed relative to several disciplines. A land use map was constructed in lab five using Anderson's system (USGS) and U-2, color-IR photography Frosted acetate was placed over the U-2 photo and the land use class boundaries were traced in pencil.

Computer analysis procedures were covered in lab six and seven. False color additive viewing was combined with single band Landsat image interpretation in six. Lab seven stressed the use of decision algorithms in a multi-spectral framework. Students were able to define a level slice and classify simulated scanner data.

Radar data was interpreted in lab eight for several land cover types and landscape features. Lab nine was devoted to a practical exam reviewing all of the material covered previously. Several stations were set-up throughout the lab and students circulated to complete the open book/notes exam.

REMOTE SENSING IN LATIN AMERICA

DAVID HUGHELL

12 March 1979

Forestry 206

Larry Fox

38

REMOTE SENSING IN LATIN AMERICA

Introduction

While remote sensing activities have become a valuable tool in resource management in developed countries they are a necessity for the wise management of natural resources in developing nations. With the increasing global scarcity of natural resources, underdeveloped nations are confronted with both external and internal pressure to develop theirs. Often there are no regulations or guidelines in the proper management of these valuable resources nor is there much information to draw upon. In the past this lack of information has given individual companies the ability to over exploit valuable resources and destroy the natural ecology of the area. The application of sophisticated remote sensing technology not only provides a quick and efficient way to locate valuable resources, but it gives those concerned a data base towork from to serve as a baseline for intensive management programs.

The advantages of satellite imagery are numerous and obvious, such as the production of a regional or national land classification map, the ability to cover large inaccessable areas, the ability to monitor an area through repeated observations, and the ability to interprete and inventory areas quickly and efficiently using digital processing techniques, to mention a few. Less well understood are the dificulties confronted by developing nations in applying this technology. Latin America provides good examples of the potential use of and the problems associated with the application of this technology. This paper will first concern itself with the difficulties associated with the application of remote sensing technology and then will review current and recent projects in Latin American Nations.

Difficulties Confronted by Underdeveloped Countries

One of the first obsticles to overcome in the initiation of a remote sensing program is the initial capital outlay for the technology and the training of the technicians to apply it. This is especially a problem in underdeveloped nations where little capital is avialable within the country and the govennment must look to foreign sources. As the potential advantages in the application of remote sensing become clearer international loans and grants are becoming more readily available. For example the Inter-American Development Bank has put 5.2 million dollars into remote sensing activities over the past five years (as of 1978) and anticipates doubling that amount with a series of new Landsat projects in several Central and South American countries (Aviation 1978).

Because most underdeveloped nations are a long ways from the sources of remote sensing technology in the United States and Western Europe the maintenance of the equipment and training of the technicians presents a problem. Brazil's space agency, the Instituto de Pesquisas Espaciais (INPE) had many problems with their Landsat programs during its first couple years of existence because film, replacement equipment, and other supplies had to come from the United States.

Another geographical problem is the variation in the areas being studied. Most remote sensing systems have been developed and tested in fairly developed temperate areas. On top of that the training sessions are often held in this type of area, or in select centralized training centers (Contiz 1977). Agriculture takes a different form in underdeveloped nations with the firlds being smaller and more dispersed. This remote sensing technology must not only be applied to, but studied and tested in these areas. A change from centralized training progrmas to scheduled regional ones is needed. This would result in sessions more oriented twoard the concerns of the local area with on-the-spot application of the technology and more local involvement. At times ~~when~~

when a trainee returns from one of the foreign training sessions this "foreign training" has qualified him/her for promotion to a different non-remote sensing job (Conitz 1977).

Individual countries should also be encouraged to develop remote sensing capabilities that will result in local analysis of the data rather than contracting it out to organizations in industrialized nations. The FAO has been critised for employing non-local people to obtain ground truth data and foreign experts for the interpretation of this data.

Concern exists in the developing countries that there is no firm assurance that programs such as Landsat will be continued beyond the technology demonstration phase. The impressive amount of remotely sensed data of earth resources of the developing nations in the past came about principally because the satellites used had on-board recording systems. A number of the newer satellites will not have this and probably will not provide earth resource data of those developing nations outside the range of a ground station. In particular, these developing nations will not derive any direct benefit from the Heat Capacity Mapping Mission (HCMM), the coherent imaging radar portion of SEASAT-1, nor the Earth Observation Satellite (EROS) (Abiodun 1977). With the ground receiving station in Brazil this should not be a concern in most Latin American Nations.

Except for a few countries, most Latin American governments are controlled by military dictatorships which presents additional problems. As the benefits of remotely sensed data become evident and political officials realize that the decalssification of such data as Landsat ~~are~~ represents almost no threat to the national security, remote sensing techniques are becoming more accepted in resource management. When Brazil became the first country to establish a Landsat ground receiving station, in 1974, security restrictions dictated that the data from the station be regarded as classified. Military approval of the applicants and their purposes was required before data could be made available to domestic users. Foreign users, except NASA scientists, were prohibited access entirely. On top of that the prices charged by the Brazilian agency in charge were so high as to discourage use. NASA threatened to shut down the Landsat satellite in the range of Brazil's station unless other countries were allowed access to the data at prices comparable to those charged by the EROS data center in Sioux Fall, South Dakota. Since then things have improved considerably with Landsat imagery now available to anyone at competitive prices (Hammond 1977).

A difficulty in the application of any new technology is the creation of an appropriate awareness of its advantages and limitations. With the unrestricted access to Landsat data a new breed of organizations are now involved in the production of "beautiful" Landsat images for use in resource management. Often these organizations have little knowledge of the local area covered yet they still portray the use of remote sensing techniques as the sole answer to many resource survey problems without acknowledging the importance of ground truthing. Many jobs are contracted out on the premise that no locally oriented company could handle the sophisticated analyses. The importance of ground truth by interpreters familiar with the area concerned must be stressed (Abiodun 1977).

Current Latin American Projects

Argentina

A five year project has been initiated which includes the purchase of equipment for a Landsat ground station and the training of 40 professionals in interpretation of the data. The price of the project could run up to 20 million dollars, part of which will come from a grant from the Inter-American Development Bank. Among the frist products will be a series of thematic maps of Argentina's resources (Aviation 1978).

Bolivia

Under the management and coordination of the Bolivian ERTS program within the bolivian Geological Survey (GEOBOL), Bolivia is using Landsat images to obtain essential information about all its natural resources. The most important aspects is the development of national thematica maps for resource planning at both the regional and local level. Examples of where this newly found information can and is being applied is in geology where Landsat imagery is helpful in the location of new mineral and petroleum deposits, and in hydrololgy in the selection of areas for hydroelectric power and irrigation development. Landsat images are also being used for preliminary design in the selection of routes for highways and oil pipelines. (Slee and Perkinson 1977).

Landsat images in conjunction with aerial surveys have been providing basic information on all natural and cultural landscapes. This will serve as a basic tool to many Bolivian agencies. It provides information on the extent and type of forest resources. Areas with extensive erosion have been identified and located for conservation organizations to coordinate rehabilitation. The census office will be using this information to aquire data on the social, economic, and geographic composition of the population (Aviation 1978).

Brazil

Brazil has made the biggest strides in the application of Landsat data. In 1974 it constructed the first Landsat ground receiving station outside of the United States and Canada. It is administed by the Instituto Nacional de Pesquisas Espaciais (INPE). Now over 300 agencies in Brazil alone are making use of the Landsat data, most of which are in the private sector. Since Argentina plans to have its own ground receiving station by 1980, formal agreements have already been made between the governments of Argentina, Brazil, and Chile to coordinate data reception and distribution to avoid unnecessary duplication of efforts (Aviation 1978).

Another spphisticated remote sensing technology Brazil has dedicated itself to with great success is the application of airborne radar in the reconnaissance of the Amazon Basin--the world's largest unknown wilderness. This project is also under INPE and is known as Radam (for radar Amazon). Essential in the Radam project is the extensive ground truthing of large areas untouched by modern man. Involved is the establishment of small landing strips and base camps in the remote parts of the Basin. From there helicopters ferry crews out to sites choosen to be representive of a certain vegetation type. First men with chainsaws strapped to their backs must be lowered to clear a landing pad. They are followed by scientific crews to take soil, vegetation, rock,etc. smaples. So little was previously known about the area that a major new tributary to the Amazon River hundreds of kilometers long was discovered and mountain ranges indicated on old maps turned out to be far from their supposed locations. Formerly it was believed the basin was covered by a relatively homogeous rain forest, but Radam has shown that instead the area is composed of a wide ranging diverse group of soil, vegetation, and mineral types (Hammond 1977).

Central American Group

Honduras, El Salvador, Costa Rica, and Guatemala are coordinating their efforts having each country define and execute a pilot study of a particular aspect of its natural resources. This involves the use of Landsat images complemented by aircraft data. A follow-up study will be the use of Landsat 3's thermal infrared data to help locate potential geothermal energy sources (Aviation 1978).

Colombia

Because of the clouds that persistantly cover many areas of the country, remote sensing activities have centered around the use of radar along with Landsat. Most of these activities are coordinated through the Inter-American Photo Interpretation Center (CIAF) in Bogotá.

To study the inundation of the lower Magdalena-Cauca ~~reive~~ river basin in the northern part of the country Landsat images taken at different times during flood state were used. This in conjunction with radar imagery provided information on drainage conditions, sedimentation patterns, and land use.(Slee and Perkinson 1977). CIAF also found success in discriminating select commercial valuable trees using airborne sidelooking radar although others must await development improved technology (Slee and Perkinson 1977).

Mexico

Mexico's development of remote sensing activities dates back to 1965 with a series of agreements between the United States space agency and its Mexican counterpart, the National Commission on Outer Space (CONEE). Their most ambitious project involves the National Water Plan which has required an inventory of ~~existing~~ all land-scapes for the entire country. Included in this is the identification of those areas with high, medium, or low agricultural and pasture potential as well as water erosion risk. This was accomplished with success through the use of Landsat imagery, aerial surveys, and ground trughing.

The feeling is that there is much potential in the application of remote sensing technology yet efforts need to be made to "show, prove, and illustrate results" to convince people that these activities should be expanded (Slee and perkinson 1977).

Peru

A project involving the use of Landsat data, aerial photos, and on the ground coverage to identify and locate the Aguaje Palm (Mauritia flexuosa) and other forest associations has recently been completed with great success. This study provides a good example of the advantages of using Landsat imagery over more conventional remote sensing techniques and the direction that should be taken in the management of a limited natural resource (Danjoy and Sadowski 1978).

The Aguaje Palm of the lowland areas of the tropical forest region of eastern Peru has recently been found to have a high potential value as a domestic source of palm oil, edible food products for human and livestock consumption, and lignocellulose for woodpulp and paper production. Instead of jumping right into a program of exploiting this newly found resource for quick economic returns the Peruvian government had an inventory of the resource and its growing conditions made. From this a master plan was developed to insure a minimal impact on the natural ecology of the area and a continual supply of this resource in the future. Only with Landsat could such a study in a short enough time to keep the delay in utilizing the palms within acceptable limits be possible. Of the 200 million Ha. of predominantly roadless tropical forest only two percent is occupied by the Aguaje Palm. The general coverage of the area by airplane was not practical because clear days were too scarce to justify keeping airplanes on standby.

The Aguaje Palm does lend intself easily for study using satellite data. Where ~~as~~ most tropical forest communities are made-up of many species, the Aguaje Palm is generally found in monospecific stands of more than 2500 hectacres in size. This, however, should not discount in itself the feasibility of applying Landsat imagery to the study of other species of interest. Not only is there a high species diversity in tropical forested regions but a wide variety of distinct plant communities with their characteristic reflectance signatures. It is not important to be able to discriminate the species of interest with Landsat but to discriminate the community of which this species is a part.

Another aspect of this study was a comparison between the manual interpretation of Landsat data using a diazo machine to create false-color composite ~~images~~ images, and digital processing techniques. Manual interpretation is important in developing countries where the aparatus are ~~is~~ often not available for the application of more sophisticated techniques. Also people unfamiliar with computers can relate better to some sort of image which has not involved the computer for its production. The authors found that ddspite the advantages associated with the manual interpretation of satellite imagery the advantages in the quality of the product and the efficiency of digital processing warrant "further testing, evaluation, and consideration for eventual operational employment in the type of application presented in this paper" (Danjoy and Sadowski 1978).

Conclusion

Despite the sophistication of the technology involved and the price tap associated with it there is an important need for advanced remote sensing techniques in developing countries, yet concern must be taken to make sure it is utilized most appropriately for the ~~individual needs of~~ informational needs of those concerned (including proper ground truthing). In the past the exploitation of resources in developing countries has often been a process of extracting them in the shortest amount of time to realize the greatest capital gains. The application of remote sensing technology has the potential of becoming a valuable tool in changing this straight forward exploitation attitude to one of wise management for future use with a minimal impact on the rest of the environment. Examples where this technology has been put to such ends were found in many Latin American Nations.

The Landsat program not only provides the capabilities for a developing nation to gather resource information at the regional or national level in a relatively short amount of time and monitor the changes by repeated coverage, but also provides political incentive for these nations to manage their resources wisely. Funding is usually needed to execute such a project which usually must come from an international source. Also just because a project involves satellite imagery there is much international interest in it. This therefore opens these projects up to the scrutiny of developed nations who, after exploiting their own, realize better the value of ones natural resources. Hopefully as the use of such information gathering tools becomes more widespread blind projects (such as the trans-Amazon highway) will become a thing of the past.

Bibliography

Abiodun, Adigun Ade 1977. The transfer of remote sensing technology in the developing nations--an observation. Eleventh International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan. April 25-29 1977. p. 339-347.

Aviation Week 1978. Latin Americ Alters View on Landsat. Aviation Week & Space Technology, July 17,1978. p. 16-17.

Conitz, Merrill W. 1977. Remote sensing utilization of developing countries: an appropriate technology. Eleventh International Symposium on Remote Sensing of Environment, Ann Arbor Michigan. April 25-29. p. 1055-1064.

Danjoy, Walter A. and Franklin G. Sadowski 1978. Use of Landsat in the study of forest classification in the tropical jungle. Symposium on the use of remote sensing by satellites for agricultural development in Latin America. May 30, 1978.

Hammond, Allen L. 1977. Remote Sensing I, II, III. Science 196:511.

Sadowski, Franklin G. 1978. The promises of remote sensing for forestry in developing countries. Symposium on the use of remote sensing by satellites for agricultural development in Latin America. May 30, 1978.

Slee, Louis F. and Jesse Dean Perkinson 1977. Via Satellite. Americas 28 No. 1:19-30.

Western Regional Applications Program Training Certificate

Applied Remote Sensing Training I

Completed by

Acting Chief
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APPENDIX II

Documentation: Faculty Involvement and Professional Development in Remote Sensing as a Result of Grant Activities

* Memoranda, Agendas, Materials for HSU Faculty Workshops

* Proposed Paper, "The Use of Guided Clustering Techniques to Analyze Landsat Data for Mapping of Forest Land Condition in Northern California" by Dr. Lawrence Fox III and Kenneth E Mayer

* Trip Report of Dr. Lawrence Fox III

* Evaluations of Dr. Rogert Hodgson

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REMOTE SENSING AND TECHNOLOGY TRANSFER PROJECT

TOM PARSONS
Director

American Indian Languages and Literature Program
Assistance to Northwest Indian Cemetery Protective Ass'n
Community Education Project
Humboldt Co Recreation Project
Indian Mainstream Industries Project
Indian Manpower Development Project (C E T A Title III Prime Sponsorship)
Kotim Een Karuk Ceremonial Society
Retired Senior Volunteer Program (Action RSVP)
Senior Nutrition Project
Student AMA American Indian Health Project
Wood for Seniors Project

DATE: October 5, 1977
DBH-77-MWorkshop

TO: Project Leaders and
Project Staff

FROM: Donna B. Hankins
Project Director

SUBJECT: October 15, 1977, Workshop

To provide a better understanding of the technology of Remote Sensing we are having a Workshop on Saturday, October 15. It is designed to give each participant basic knowledge regarding the technology and its applications in your discipline field.

The morning session will give an overview of the theoretical aspects of Remote Sensing. The afternoon will be devoted to a series of exercises which will enable each individual to utilize the information gained in the morning.

Due to the limited amount of time and materials we do need to limit the amount of participants. Those receiving this invitation are those who have been contacted beforehand.

Enclosed please find the following:
1. Agenda for Workshop
2. Background information needed to be reviewed.
   a. Olsen article on Photographic Interpretation.
   b. Definition of scale.

Also, please review (if possible) the July 1976 National Geographic article on Landsat.

Looking forward to seeing you on: October 15
9:00 a.m. to 4.00 p.m.
Forestry, Rm. 203 (HSU)

IN COOPERATION WITH CALIFORNIA'S NORTHWEST COUNTIES

OUTLINE FOR ONE DAY SHORT COURSE
ON REMOTE SENSING

Given Oct. 15,
Saturday in
Forestry 203

9:00 - 9:45	Theory of Automated Processing - Feature Space vs. Image Space
9:50 - 11:15	Exercise - Two Channel Level Slice
11:30 - 12:15	Slide Presentation - The steps involved in processing with interactive computers
LUNCH	
1:15 - 2:00	Points of Field Data Collection Review of Scale, Stereo Perception test EROS Data Center - how to order
2:00 - 3:00	Exercise - Panchromatic photo-interpretation (optional discussion on Landsat for those already familiar with this)
3:00 - 4:00	Exercise - Low altitude, color photo interpretation

BY WHAT processes does man interpret the environment that surrounds him through the images formed by reflected light? The answers to this question are only partially known. Man has binocular vision and because of the parallax displacement of his eyes he is able to view this world stereoscopically with three-dimensional vision. This stereoscopic vision and associated depth perception are important methods in the interpretation of the environment. Also, man gets an oblique or angular view of most objects he observes. The experiences, training, and education that an observer has developed in a lifetime of viewing his surroundings diminish in value—and are perhaps even a hindrance—when he observes and tries to interpret a vertical air photograph. The photograph is flat, or two-dimensional, unless viewed stereoscopically. In the black and white mode, objects have no revealing colors. Objects are imaged at greatly reduced scale. Finally, if the observer is looking at a vertical air photograph, he is presented with a nonoblique view of a world he can experience only from an airplane or spacecraft. As a result, some elements on the photograph assume a greater importance in image interpretation.

The interpreter must pay special attention to characteristics and clues which can be identified on the image. In the final analysis, although anyone can be trained to read a photograph, a really good interpreter has an almost intuitive understanding of the peculiar view presented to him on the imagery! We can define photo-interpretation as the identification of objects on photographs and the determination of their meaning or significance. In broader terms this definition applies to the entire discipline of remote sensing.

11-What is Photographic Interpretation?

CHARLES E. OLSON, JR

PHOTOGRAPHIC INTERPRETATION is defined by the American Society of Photogrammetry (1960) as "The act of examining photographic images for the purpose of identifying objects and judging their significance."

Almost every individual engages in photographic interpretation. Books, newspapers, magazines, billboards and television all offer photographs to look at, and with each look the observer gains ideas or impressions about something. These ideas or impressions are actually photographic interpretations. Such interpretations may be conscious or unconscious, accurate or inaccurate, complete or partial, but interpretation is an essential part of the process through which information is obtained from photographic images.

A photographic interpreter, or photointerpreter, is an individual specially trained or skilled in photographic interpretation. Because of his training or skill, the photointerpreter is better able to identify objects from their photographic images and can more accurately and completely judge the significance of these objects than can an unskilled or untrained observer.

Prepared for 1969 Summer Short Course in Fundamentals of Remote Sensing at the University of Michigan, Ann Arbor, Mich. Reprinted with permission of the author.

Photographs as Graphic Records

Civilization and man's ability to communicate developed together. People may argue about the order in which communication media developed, but all agree that drawings came early. Man's first drawings may have been finger markings in the dirt which approximated the shape of things that he had seen. When some indication of size, or scale, was added, his drawings became more meaningful. Color and indications of fur, hide, or texture have been found in early drawings of the cave man, indicating that the importance of these qualities was recognized at an early date. As man and man's civilization advanced, his ability to communicate improved. Languages became more expressive and drawings more detailed. Such things as shading and shadows, repetition of patterns, and combinations of related features were added. These additions improved his graphics, but man was not satisfied. He wanted a complete picture of what he had seen, and he kept searching for some way to record what his eye actually saw

The search for better graphic records led to the photographic process, but the road was a long one and progress was neither direct nor steady Aristotle's concern with the nature of light (approximately 384–322 B.C.) was an early prelude to photography Actually, the word "photography" was derived from Greek and means "to draw with light"

A photograph is nothing more nor less than a graphic record of energy intensities

Today, and increasingly in the years to come, photographic interpreters should not limit their consideration to images or records produced with visible light A photograph records the intensity of energy received at the focal plane of the taking camera By varying the characteristics of the recording system, we can obtain records representing wavelengths of energy in many parts of the electromagnetic spectrum Each part of the electromagnetic spectrum can provide useful information, and most photographic interpreters will have to work with graphic records from several parts of the spectrum Their field of interest includes the entire electromagnetic spectrum and the images that can be produced with many sensors Unfortunately, the mechanics involved in obtaining the photographic, or just graphic, images from several sensors cause us to lose sight of the basic situation that brought these sensors into existence Man's search for better graphic records led to photographs and *any photograph, regardless of its origin or the type of images displayed, is nothing more nor less than a graphic record*

Elements of Photographic Interpretation

Photographic records come in many shapes and sizes and represent energy in many parts of the spectrum Photographic interpretation is essential to the effective use of these records, and interpreters should be prepared to handle them Interpretation of these varied records is not as difficult as it may appear, for the elements of photographic interpretation apply to all graphic records regardless of the nature of the sensing system that produced them or the portion of the electromagnetic spectrum represented While a thorough knowledge of the characteristics of the sensing system is of immense value, interpretations of graphic records are always based on one or more specific properties of the images making up the record at hand These properties are sometimes called elements of photographic interpretation For interpretation of photographic records requires either conscious or unconscious consideration of one or more of them, and preferably of all of them (Olson 1960)

Nine elements of photographic interpretation are described in the following paragraphs The discussion is not intended to be exhaustive for a separate book could be written about each of them Appreciation of the importance of these elements grows with experience and practice

1 *Shape* The shape or form of some objects is so distinctive that their images may be identified solely from this criterion The Pentagon Building near Washington D C , is a classic example

2 *Size* In many cases, length, width, height area and/or volume are essential to accurate and complete interpretation The volume of wood which could be cut from the stand in Figure 1 is dependent upon tree size stand density, and size (or area) of the stand

3 *Tone* Different objects reflect and emit different amounts and wavelengths of energy These differences are recorded as tonal, color, or density variations in the record The stand of mixed hardwoods shown in Figure 1 was photographed in late October at the peak of the fall color change Species differences show clearly in different tones or shades of gray

4 *Shadow* Shadows can help or hinder the interpreter, for they reveal invisible silhouettes but hide some detail Shadows in Figure 2 provide information on the size and shape of this building which is not apparent from the image of the building alone These same shadows obscure detail in the lawn and sidewalk areas in front of the building

5 *Pattern* Pattern, or repetition, is characteristic of many manmade objects and of some natural features The land use pattern shown in Figure 3 is typical of areas of deep, windblown soils Orchards and strip cropping are particularly conspicuous because of pattern

6 *Texture* The visual impressions of roughness or smoothness created by some images are often valuable clues in interpretation Tree size is often interpreted on the basis of apparent texture Smooth velvety textures are commonly associated with young saplings, while rougher, cobbled textures usually indicate older trees of sawtimber size

7 *Site* The location of objects with respect to terrain features or other objects is often helpful The open pond and the flatness of the area of dark-toned vegetation in Figure 4 both indicate a coniferous swamp In this area of Michigan northern white cedar balsam fir and black spruce are the predominant swamp conifers The stand shown here is actually a mixture of these species

8 *Association* Some objects are commonly associated with other objects that one tends to indicate or confirm the other In Figure 5 the two tall smokestacks large building coal piles conveyors and cooling towers are obviously related This combination and arrangement of features identify the installation as a thermal power plant

9 *Resolution,* Resolution depends on many things but it always places a practical limit on interpretation Some objects are too small or otherwise lacking to form a distinct image on the photograph The lake in Figure 6 shows some interesting tonal patterns but the exact location of the shoreline is not visible along much of the boundary of the lake The shoreline failed to resolve because of insufficient tonal contrast between adjacent land and water surfaces

Note that seven items on this list are qualities that man developed in his early drawings The last three items are important to interpretation because they tend to integrate or set limits on the others In 1951, Colwell presented a concise statement showing how integration of interpretations of several photographic images could lead to accurate interpretation of conditions not directly visible in the photograph He called this approach the

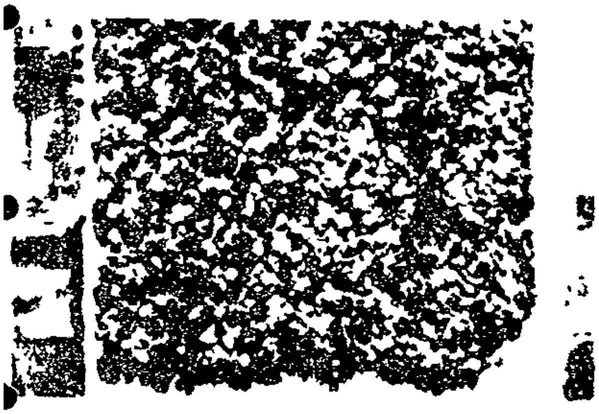

Figure 1 Panchromatic minus blue photograph of mixed hardwood stand at the peak of the fall color change Lightest toned tree crowns are sugar maple, dark-toned crowns are generally oak (University of Illinois)

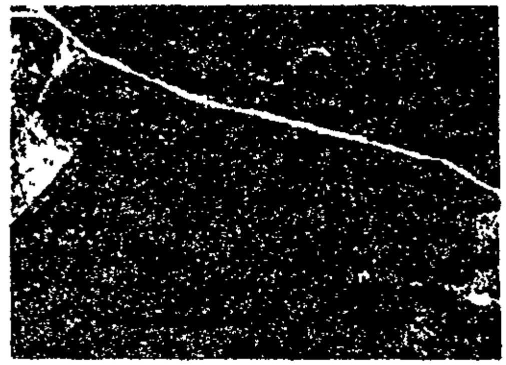

Figure 4 Black spruce, northern white cedar, and balsam fir in swampy area in Leelanau County, Michigan (University of Illinois)

Figure 2 The shadow of this building shows the steeple more clearly than does the image of the steeple itself (University of Illinois)

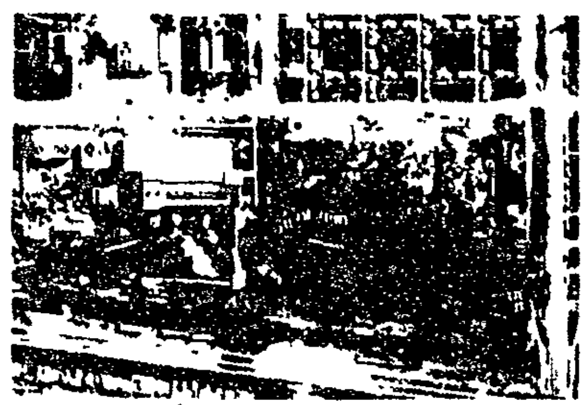

Figure 5 Thermal power plant at the University of Illinois (University of Illinois)

Figure 3 Land use pattern on loess in Calhoun County, Illinois (U S D A)

Figure 6 Shallow water revealed by tonal contrast, although exact shoreline is not resolved, Leelanau County, Michigan (University of Illinois)

convergence of evidence Integration of several of the elements of photographic interpretation is essential to any interpretation and contributes to the convergence-of-evidence frame of mind Association, in particular, is closely related to this convergence-of-evidence concept

The Philosophy of Photographic Interpretation

In recent years, photographic interpretation has been called a new natural science (Lueder, 1959, 1961) An increasing volume of literature has appeared, and is appearing, that attempts to establish rules or procedures for photointerpretation (Kedar, 1958, Lueder, 1959, Stone, 1956). However, no single, best method of procedure has evolved which is acceptable to even a majority of photointerpreters It is generally agreed that the interpreter should work methodically, should proceed from general considerations to specific details, and should proceed from known to unknown features (Stone, 1956) Methodical work and interpretation of known features before evaluating the new and unknown features are almost axiomatic in scientific endeavors Proceeding from general to specific considerations is also desirable as long as the considerations of general (sometimes called regional) features do not bias the interpretation of the specifics Specific, local considerations often provide the evidence needed to complete or confirm the broader regional pattern In most cases, general and specific features must be considered together To say that one must come before the other can be misleading To go further than this and propose that interpretation should proceed from one specific group of features to another is an unwarranted channelization of the infinite variation that the photointerpreter encounters

Drainage, landform, vegetation, and man's activities are thoroughly scrambled in most photographs, and each feature may be indicative of the nature of the others For this reason, the photointerpreter should be terrain-conscious in the broad sense of terrain He should understand that the images he interprets make up a terrain and that the terrain he deals with is a complex series of interrelated features academically catalogued as agriculture, botany, geology, engineering etc The importance of these interrelationships was clearly expressed by C H Summerson (1954) when he said

> The subject matter of the photointerpreter is as broad as the earth itself, upon the earth's surface is a tremendously varied pattern of natural features, upon which man has superimposed an equally varied cultural pattern . Where there are so many varied objects to be considered, our first inclination is to classify Classification is indeed necessary, but it must always be remembered that groupings are manmade and not natural Conclusions based on empirical identifications of isolated elements in a terrain may often be very inaccurate The knowledge that no region is a static thing greatly aids the interpreter in his understanding of the terrain

Because aerial photographs record images of all types of terrain features, photointerpretation has become a valuable tool in each of the earth sciences, and in several other fields as well However, photointerpretation cannot be confined to geology, forestry, soils, or any single field and remain effective The photointerpreter must consider all of the factors making up any terrain even when his special interest may be directly solely to geology, forestry, agronomy, or engineering *Failure to give adequate consideration to all aspects of a terrain is a major cause of misinterpretations* Belcher (1957) put it this way during a discussion of correlations between man's activity and his environment

> the average interpreter does not know many things and he doesn't realize his lack of knowledge If he places two elements of the environment together and pulls a boner, it isn't because the environment is wrong, instead it's because there were three other elements that he ignored or didn't know were there.

The Photographic Interpretation Process

Photographic interpretation is a deductive process and features that can be recognized and identified directly lead the photointerpreter to the identification and location of other features in the terrain under consideration Even though all aspects of a terrain are irreversibly intertwined, the photointerpreter must start some place He can't consider drainage, landform, vegetation, and manmade features simultaneously He must start with one feature or group of features and then go on to the others, integrating each of the facets of the terrain as he goes In all probability, no one starting point will satisfy or be best for, all interpreters or for any one interpreter all of the time For each terrain, the interpreter must find his own point of beginning and then consider each of the various aspects of the terrain in logical fashion

The deductive process which is photographic interpretation requires conscious or unconscious consideration of the elements of photographic interpretation listed earlier The completeness and accuracy of photointerpretation are proportional to the interpreter's understanding of how and why photographic images show shape size tone, shadow, pattern and texture, while an understanding of site, association and resolution strengthens the interpreter's ability to integrate the different features making up a terrain For the beginning interpreter systematic consideration of the elements of photographic interpretation should precede integrated terrain interpretation Mastery of the elements of photographic interpretation is seldom possible however before the interpreter gains considerable experience in terrain interpretation

Photographic Interpretation and Photogrammetry

Interest in photointerpretation has been stimulated during the last 15 years, or more, by outstanding successes achieved through photointerpretation of aerial photography for military and civilian purposes Without question, early and continuing development of instruments permitting precise measurement and mapping from aerial photographs contributed to these photointerpretation successes Since these instruments are usually considered tools of photogrammetry it is sometimes difficult to distinguish between photogrammetry and photographic interpretation

Photogrammetry is defined by the American Society of Photogrammetry (1960) as "The science or art of obtaining reliable measurements by means of photographs."

Photographic interpretation was defined by the same source at the beginning of these notes as "The act of examining photographic images for the purpose of identifying objects and judging their significance."

From these definitions it is clear that the photogrammetrist (as the specialist in photogrammetry is called) is primarily concerned with measuring and the photointerpreter with identifying and judging significance. It should also be clear that the photogrammetrist cannot make a measurement unless he first identifies what he is going to measure and that the photointerpreter must often measure to arrive at a final identification and his judgment of significance.

Interpretation of Aerial Photographs

Vertical aerial photographs—those taken with the optical axis of the camera pointed vertically downwards toward the earth—are the most common graphic records encountered by photointerpreters. This does not mean that vertical photographs are always best for interpretation purposes, for oblique photographs can provide tremendous amounts of information. It just happens that the advantages of vertical photographs for photogrammetric mapping purposes are so great, and the amount of mapping photography so plentiful that vertical photographs are more readily available than all other types of aerial imagery.

Interpretation of vertical aerial photographs is sometimes difficult for the beginner. Everyone is used to the oblique perspective that we see every day with our own eyeballs, but the plan view observed when looking down on the tops of objects is much less familiar. Being less familiar, in plan view many objects are more difficult to identify from vertical than from oblique air photos. Despite this, correct integration of clues gained from an assessment of the nine elements of interpretation mentioned earlier can lead to consistently accurate results. Brief looks at how each of the elements of interpretation can contribute to correct interpretations follow. The discussion is not intended to be exhaustive, and some elements are treated at greater length than others. Taken together, however, they provide a starting point from which interpretation of the complex interrelationships portrayed in aerial photographs can begin.

Shape

One of the most outstanding examples of shape as a factor in interpretation is found in the almost instantaneous recognition of the Pentagon Building in Washington, D.C., because of its shape. All shapes are not this diagnostic, but every shape is of significance to the photographic interpreter. Stated another way, "The shape of any image is a factor that the interpreter should consider when interpreting that image."

Consideration of shape should include consideration of total form. Relative proportions of length to width, height to length or width, etc., are just as important as generalized outlines seen in plan or profile view.

When geometric shapes are present, man's activity is almost always indicated. Symmetric, straight, or perpendicular forms are rare in nature, but do occur in geologic features such as domes, faults, and bedding planes. Also, old fire scars and storm damage can give rise to straight and/or angular boundaries between vegetative-types. In any case, the presence or absence of definite shapes should be observed and noted by the interpreter.

Linear Features

Linear features—those that are exceptionally long compared to their width—are some of the most obvious images in photographs. Roads, railroads, power lines, and streams are some of the most important of these, but the interpreter needs to be alert to even the less obvious linear elements in the terrain he is interpreting. Even distinguishing between the more obvious linear elements presents some difficulties, but the following observations may be helpful.

Railroads are characterized by broad sweeping curves and the complete absence of sharp corners, except at crossovers which are relatively rare. Grades are relatively flat, when compared with highways, and cuts and fills are common. The roadbed is continuous and bridges will be present where the railroad crosses streams and significant ravines.

Highways and roads resemble railroads, but have sharp corners and right-angle intersections. Grades are steeper than with railroads, and highways tend to follow the contour of the ground with fewer cuts and fills. Bridges are common (where needed), but many small streams have earth-fill over culverts instead of bridges. When side by side, highways often swing away from the railroad going through small towns, but the railroad usually goes straight through. While it is true that the newer superhighways have grade and alignment characteristics resembling railroads, the dual lanes with wide median strips and the presence of cloverleaf interchanges permit ready interpretation in almost all cases.

Electric transmission lines are straight, or composed of straight segments, and tend to cross the terrain with no reference to topography. Trees are cleared from rights-of-way and this leaves a narrow, but distinctive, scar through forested areas. Sometimes poles or pylons are visible, but not at the smaller scales often encountered by the photointerpreter. Pole locations can sometimes be identified from the mound of subsoil left after digging the postholes. In some cases, the wires themselves can be seen, even at scales as small as 1:20,000. Electric transmission lines cross streams and ravines without bridges, but maintenance roads may be visible along the otherwise clear pole line.

Gas pipelines resemble electric transmission lines, but seldom have maintenance roads along them and are less oblivious to topography. A continuous line of subsoil, left after digging the ditch for the pipe, persists as a distinctive feature for years. In some areas, pipelines can be seen in aerial photographs as light-toned streaks crossing corn fields even though the photographs were taken more than ten years after the pipeline was constructed. Even where cropping is continuous, the soil disturbance associated with the pipeline produces different light reflectances than the undisturbed areas adjacent to it, and these may well persist for more than ten years. To simplify tunneling under existing roads, pipelines often bend sharply towards the road just before the point where the tunneling begins This jog in the path of the linear feature is rare with power lines

Fence lines are difficult to identify except when land use is different on the two sides of the fence Once land use has been established for a long period of time the fence lines may be quite obvious in aerial photographs even decades after the land use pattern has been abandoned This is particularly true of old farms that have been planted to trees or allowed to reseed naturally

Streams are seldom confused with other linear features because of their irregular shape, varying width, and complete dependence on topography

Drainage ditches are common in flat lands and are usually easy to separate from natural streams because of their distinct tendency to be straight and have uniform width A trail of dredged material may be visible on one or both banks of the ditch Some confusion may arise where existing stream channels are improved to facilitate drainage, with or without a realignment of the channel, but careful consideration of the total drainage pattern usually indicates the true situation In some areas, ditches are used to transport irrigation water from mountain reservoirs to dryer valleys and plains In these valleys, irrigation ditches may resemble the drainage ditches of other areas Once again complete consideration of the drainage system (or irrigation system) will clear the air

Geologic faults are linear features that can be quite obvious when prominent rock structures are truncated or roads displaced In other cases and especially after extensive weathering faults may be very difficult to recognize

Dams are shorter than the features discussed above, but may well be mentioned at this point Straight or smoothly curving sections of shoreline should be studied carefully to be sure that that piece of beach isn't actually the dam that indicates an artificial lake as opposed to a natural one The presence of the dam may indicate the work of man and suggest other manmade features in the same area However all dams are not manmade and beaver dams more than a mile in length are known

Tree Species

Shape is often an aid in interpreting tree species, for branching habits and total form vary from genus to genus, and in some cases between species within a genus Shadows often provide a profile view which helps in tree identification

Soil Texture

Soil texture can often be determined from aerial photographs if careful attention is paid to the cross sectional shape of the small gullies that are present Several factors have to be considered and it is easy to make errors, especially when hardpans or abrupt changes in soil texture with depth produce compound gully shapes

Size

The fact that some objects are bigger than others should need no special mention but beginning interpreters often forget that relative sizes of different objects in a single photograph can provide valuable clues Some objects are readily identifiable and can be used as guides to the approximate sizes of other objects that are not so easily recognized In many cases however relative size is not enough and the interpreter must use some of the techniques of the photogrammetrist These will not be discussed in detail, but some indication of the possibilities seems in order

Distance

The distance between two points, or the length of an object, can be determined from an aerial photograph The accuracy of such measurements is a function of photo scale and the accuracy of the photo measurement On standard USDA photography at a scale of 1 20,000 a careful interpreter can usually determine distances to an accuracy of approximately ± 5 feet When the ends of the distance(s) measured are at significantly different ground elevations, accuracy usually decreases

Height

The heights of objects or differences in elevation between ground points can be determined from air photographs Several methods are available but the best is that based upon differences in parallax between two vertical photographs of an object taken from different points in space Stereoscopic photography is required Careful work can provide spot height data (i e, height of a tree or building) accurate to within ± 1/2000 of the flying height Topographic mapping or contouring can be performed to somewhat lower accuracy Contouring requires continuous determination of spot elevations and is more difficult than determining the height of a single small object

Area

Determination of the area of irregular parcels is more easily accomplished from vertical photographs than with ground methods Accuracy is limited by scale and slope, but has been found acceptable for most natural resource purposes In rough terrain, it is often easiest to transfer boundaries from the photographs to a planimetric map and then determine the area of the parcels of interest from the map boundaries

Volume

Many organizations with large quantities of raw materials routinely use aerial photographs to determine the volume of material in open piles Photogrammetrically determined volumes have proven accurate enough to permit useful estimations of the quantity of the finished product produced by the plant

Tone

Tone whether the shade of gray in a black and white photograph or the combination of hue, chroma, and saturation in a color photograph conveys more information to an alert, knowledgeable interpreter than any other single element of interpretation In almost all cases however, it is the difference in tone between objects or between an object and its background which is important In fact without a difference in tone between the background and the edge of an object there can be no detectable image

Relative tone can be quantified by measuring the amount of light transmitted through a photographic negative or other transparency. As the amount of silver present increases the amount of light transmitted decreases and we say that we have a denser or darker-toned image. Microdensitometers exist that can scan photographs at reasonably high rates of speed. If the output of such an instrument were plotted for single scans across a photograph we might get plots such as those shown in Figure 7. The total range of density is greater in trace A than in B, but due to the uniform change in density across the photograph no images would be detectable in the strip of the photograph represented by trace A. The second trace (B) shows two distinct images. Notice, however, that the slope of the trace indicates that there is a much sharper change in density at the edges of image one than at the edges of image two. The slope of the microdensitometer trace or the *edge gradient* (Fox, 1957) indicates that image one will be sharper and easier to resolve than image two. The second image may blend with its background and appear as a small blob rather than an object of distinct shape.

Colwell (1959) described the significance of tone and edge gradient in much the same fashion when he listed three primary characteristics governing the quality of photographic images for photointerpretation. These were:

1. *Tone contrast*, or "the difference in brightness between an image and its background."

2. *Image sharpness*, or "the abruptness with which the tone or color contrast appears to take place on the photograph."

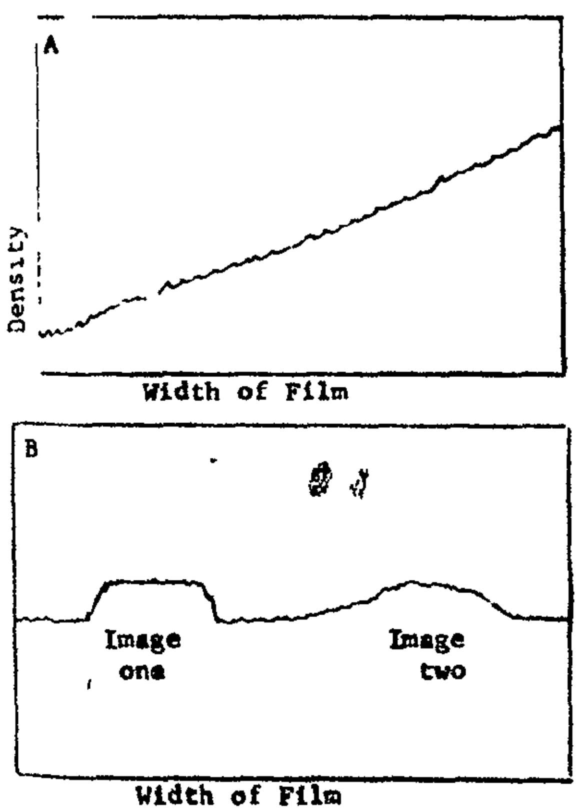

Figure 7 Potential microdensitometer traces at two different locations.

3. *Stereoscopic parallax*, or "the displacement of the apparent position of a body with respect to a reference point or system caused by a shift in the point of observation."

Colwell's first two characteristics have just been discussed, and the third was mentioned in the remarks under Size-Height.[1]

Shadow

In addition to providing a silhouette, the presence or absence of shadows—and shadow length—provides an immediate index of the relative height of different objects in a photograph. Shadows are often the best indication of relative heights of objects when looking at a single photograph where the advantages of the stereoscopic view provided by overlapping photos are not obtainable. Compare the shadow lengths of the smoke stacks and various buildings in Figure 5, as an example.

Pattern

Land use patterns are often distinctive. Agricultural practices, in particular, leave clues as to what has taken place that can provide positive indication of the crop present. Row patterns in corn and soybean fields separate them from wheat fields and pastures and lack such patterns. Wave patterns along coastlines often reveal the presence of submerged obstacles, such as sandbars and reefs, even though the obstacle cannot be imaged directly.

Texture

Texture, like pattern, is often related to land use. Planted vegetation usually appears in smoother textures than natural vegetation. As abandoned agricultural areas revert to forest, encroachment by woody species results in a rougher texture of fields that may or may not be accompanied by obvious tonal differences. Eventually, this encroachment produces a mottling which is a distinctive disruption of the previous uniformity of the active fields.

Site

Just as some tree species grow in swamps and others on dry upland ridges, so some manmade objects are found along rivers and others on hilltops. Thermal power plants need an abundant supply of coolant water and are often (but not always) found near major streams. Hydroelectric plants must have water under pressure and are always associated with a natural or manmade water supply. Early warning radar stations, on the other hand, are usually placed on high promontories to minimize terrain interference with the line of sight of the radars.

Association

Association is often one of the most helpful clues to the identity of manmade installations. The manufacture of aluminum requires large quantities of electric power

[1] A section on factors controlling tone in aerial photographs has been deleted with the author's permission. This included a discussion of the energy flow profile for a camera system, light reflectance properties of trees, photographic tone of tree foliage and photographic tone in water areas, and also Figures 8–14.

Absence of the power supply rules out this industry Schools usually have associated playgrounds and athletic fields while churches do not Large farm silos are an indication that livestock are (or were) present Unexpectedly large culverts or bridge spans across small streams indicate that heavy runoff occurs frequently enough to require the engineering works necessary to cope with the water when it comes

To the military interpreter, the presence of antiaircraft guns is almost positive proof of the presence of a target worth defending. If he hasn't found it, he had best look again

Resolution

The ability of a photographic system (including lens, filter, emulsion, exposure, and processing, as well as other factors) to record fine detail in a distinguishable manner is referred to as the resolution, or resolving power, of the system Unfortunately, resolution is one of the most misunderstood and misused qualities of the photographic system—at least by most photographic interpreters

Resolving power depends on many factors The first and often overlooked requirement is that a difference exists in the energy reaching the focal plane from the object and its background If there is no such difference then nothing that the recording system can do will create a discernible image

The importance of tone contrast and edge gradient were included in the discussion of tone It should be clear that resolution is related to edge gradient If the difference in density across an edge is great enough to be detectable, then the steeper the edge gradient the greater the probability that the density change will be detectable as a visible change in tone of the photograph

Edge gradients are influenced by the total photographic exposure, or the total energy involved in producing a particular image Steep gradients are usually associated with intermediate exposures and lower gradients occur at both extremes Thus, resolution falls off at high or low exposure levels, compared to the maximum resolution achieved at some intermediate exposure This loss in resolution is one of the major reasons why significant over or underexposures are undesirable and is a major problem encountered by the interpreter who must work with imagery containing both very light and very dark images in the some photograph The washed-out appearance of broad-leaved trees imaged in infrared photographs is partially due to the loss of resolution that accompanies the overexposure of the trees when the overall photographic exposure is set to record less reflective objects occurring in the same terrain Also the loss of resolution observed in shadowed areas is due to the fact that objects in the shaded areas reflect so little light to the camera that they are underexposed

Photographic interpreters are often confused by errors in assessing resolution When telephone wires resolve it does not necessarily follow that any object the thickness of a telephone wire will resolve The wire (or a paint line on a parking lot) is detectable because its length results in exposure to several silver halide grains, rather than because the camera system can resolve very small images Resolution of the familiar USDA photography at a scale of 1 20,000 is such that round or square objects less than 2 5 feet across are seldom discernible When measuring tree heights, interpreters usually do quite well with round-topped trees like large oak and maple, but poorly with trees having sharp-pointed crowns like balsam-fir or spruce The crown of a balsam-fir may extend 10 or 15 feet higher than the point where its diameter narrows to 2 5 feet

The tone of the background affects resolution of small objects Photographic emulsions can act as a scattering media and some of the energy from highly reflective (bright) objects may cause exposure of silver halide grains adjacent to those at the geometric location of the object Bright objects against a dark background will appear larger than they actually are, but dark objects against a bright background will appear smaller than they actually are Small bushes on a white sand beach often fail to resolve because lateral irradiation of adjacent grains results in exposure of the grains that should have remained unexposed to mark the location of the bush

REFERENCES

American Society of Photogrammetry *Manual of Photographic Interpretation* Washington, D C , 1960

Belcher, D J Remarks made during discussion of a paper by G R Heath (below) and published in *Photogram Engng* 23 114, 1957

Colwell, R N A systematic analysis of some factors affecting photographic interpretation *Photogram Engng* 20 433, 1954

Colwell, R N The future of photogrammetry and photo interpretation *Photogram Engng* 25 712, 1959

Fox, R I Visual discrimination as a function of stimulus size, shape and edge gradient Boston University Technical Note No 132, 1957 52 pp

Heath, G R Correlations between man's activity and his environment which may be analyzed by photo interpretation *Photogram Engng* 23 108 1957

Kedar Y A geographic approach to the study of photographic interpretation *Photogram Engng* 24 821, 1958

Lueder, D R *Aerial Photographic Interpretation Principles and Application* New York McGraw Hill 1959

Lueder, D R Photo interpretation as a new natural science Paper presented at the Annual Meeting of the American Society of Photogrammetry, Shoreham Hotel Washington D C March 21 1961

Olson, C E , Jr Elements of photographic interpretation common to several sensors *Photogram Engng* 26 651, 1960

Seymour T D The interpretation of unidentified information—a basic concept *Photogram Engng* 23 115, 1957

Stone K H Air photo interpretation procedures *Photogram Engng* 22 123 1956

Summerson C H A philosophy for photo interpreters *Photogram Engng* 20 396, 1954

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IMAGERY CHARACTERISTICS

Many texts, journal articles and documents are available on the science of remote sensing in general, and the individual technologies of aerial and space imaging. We refer the reader who is interested in an in-depth treatment of these topics to these many excellent sources. From the context of understanding some of the basic terminology and characteristics of aerial and space imagery referred to in this handbook, this section presents a brief introduction to these concepts.

Scale Factor

The fundamental characteristic of aerial/space images determining how much ground area is covered and what can be seen or detected on the image is scale factor. This is expressed as a representative fraction (RF) and is a function of the camera focal length over the height of the platform above the terrain at the time the photograph is taken. Thus, for a conventional vertical aerial photo that is taken with a 6 inch focal length camera from an aircraft flying at 10,000 feet above the ground, the scale would be

$$RF = \frac{0.5 \text{ ft } (6 \text{ inches})}{10{,}000 \text{ ft}} = \frac{1}{20{,}000}$$

or

$$RF = 1:20{,}000$$

The scale factor is determined for the original negative and is often referred to as contact scale Enlargements of the image, of course change the resultant scale factor proportionately

Table 1 – Representative space and aerial image scale characteristics

Scale Factor	Feet per Inch	Area Covered per Frame (9" x 9" Film Format) Statute Miles	Nautical Miles	Comments
1 1,000,000	83,333	115 x 115	100 x 100	LANDSAT (ERTS) images enlarged to this scale (3 7X)
1 715 000	59,583	101 x 101	88 x 88	Skylab S-190A photos enlarged to this scale (4X)
1 473,000	39,417	68 x 68	59 x 59	Skylab S-190B photos enlarged to this scale (2X)
1 130,000	10 833	18 5 x 18 5	16 x 16	Typical NASA U 2 image scale/format, 6" focal length
1 120,000	10,000	17 x 17	14 8 x 14 8	Typical NASA RB 57 image scale/format 6" focal length
1 80,000	6,666	11 4 x 11 4	9 9 x 9.9	Typical USGS 'High altitude" photo scale for mapping
1 63,360	5 280	9 x 9	7 8 x 7.8	1 mile per inch scale – Alaska topographic quadrangle map series
1 50,000	4,167	7 1 x 7 1	6 2 x 6.2	Will become more common scale as metric system adopted
1 40,000	3,333	5.7 x 5 7	4 9 x 4.9	Typical scale (current) of USGS and USDA mapping photography
1 24 000	2,000	3 4 x 3 4	3 x 3	Scale of USGS standard topographic map series (7½' quadrangles)
1 20 000	1,667	2 8 x 2 8	2 5 x 2 5	Typical scale of older USDA and USGS mapping photography
1 15 840	1 320	2 25 x 2 25	2 x 2	Typical scale of Forest Service photography – ¼ mile per inch
1 12,000	1,000	1 7 x 1 7	1 5 x 1 5	Typical "large" scale for detailed photogrammetric surveys
1 4,800	400	0 7 x 0 7	0 6 x 0 6	Very large scale for detailed surveys – usually very limited area
1 2,400	200	1/3 x 1/3	0 3 x 0 3	Very large scale for detailed surveys – usually very limited area

The RF or scale factor, like a map, expresses the relationship that one unit of measurement (any unit) on the image represents so many units of actual ground distance This has led to the other commonly used convention of stating scale factor in "feet per inch" – i e , so many feet of actual ground distance are represented by one inch of photodistance Table 1 lists representative scale factors of typical aerial and space images expressed both in RF and feet per inch A single scale factor generally represents an image of vertical, or straight down, orientation With oblique, or tilted images, however, no uniform scale exists The great majority of aerial and space imagery is vertical though some of the early space photos, particularly the hand-held camera photos of the Gemini and Apollo series, and some aircraft camera configurations, are oblique Two terms are used to differentiate the relative angle of obliquity – in a high oblique the horizon is showing, in a low oblique it isn't

Area of Coverage/Format

The area covered by a single aerial or space photo is determined by its scale factor (focal length/altitude) and the image format size, or field of view Figure 1 portrays the relationship of the characteristics of vertical aerial or space photos Altitude, focal length, and format determine the scale and area of coverage on the image The figure illustrates the principle of stereo, overlapping photographs which is the predominant mode in use

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REMOTE SENSING AND TECHNOLOGY TRANSFER PROJECT

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Director

American Indian Languages and Literature Program

Assistance to Northwest Indian Cemetery Protective Ass'n

Community Education Project

Humboldt Co Recreation Project

Indian Mainstream Industries Project

Indian Manpower Development Project (C E T A. Title III Prime Sponsorship)

Kotim Een Karuk Ceremonial Society

Retired Senior Volunteer Program (Action - RSVP)

Senior Nutrition Project

Student AMA American Indian Health Project

Wood for Seniors Project

M E M O R A N D U M

DATE: December 6, 1977
JLW-77-MFaculty

TO: Workshop Participants

FROM: Joseph Webster JLW.
Remote Sensing Project

SUBJECT: Goals and Objectives from December 3rd Workshop

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The attached is the list of goals and objectives decided upon at the December 3rd Workshop session. They are listed first, in the order of presentation and, second, the overall consensus of the group according to priority. These goals and objectives will be combined with those developed from the January 7th session. You will receive a copy of those items after the January 7 session.

If you have any suggestions concerning this list, or additions, please feel free to do so.

Thank you.

FACULTY WORKSHOP - December 3, 1977

ACTION ITEMS
-considered by participants

1. Establish a coordinating committee for University Remote Sensing Center.
2. Develop a cadre of instructors knowledgeable in Remote Sensing at HSU.
3. Apply for personal grants.
4. Obtain equipment for training.
5. Examine the goals of a remote sensing institute in respect to HSUniversity goals and outline the benefits and limitations of such an institute.
6. Develop a coordinated proposal for summer '78 training for five (5) professors.
7. Investigate other resources besides NASA for peripheral grants.
8. Seek outside consulting group for assistance in developing remote sensing capabilities at HSU.
9. Develop the criterias for courses in remote sensing in university and levels of instruction.
10. Community workshops and awareness programs beyond University.
11. Integration of remote sensing resources and instruction efforts with existing efforts of instruction at HSU.
12. Establish departmental priorities for remote sensing at HSU.
13. Secure community input and needs for remote sensing and utilize techniques of the School of Behavioral and Social Sciences to gain this information.
14. Gain a broad range of input from potential and actual users, technologists, and universities in reference to remote sensing.
15. Present program of remote sensing to University in reference to "space" priorities.
16. Development of a Graduate Curriculum in Remote Sensing.
17. Explore alternative avenues to reach curricular goals in remote sensing.
18. Investigate the Administrative jurisdiction of a Remote Sensing Institute at HSU.
19. Obtain director and develop an implementation plan.

The participants established the following as the number one and two priorities for HSU faculty:

1. Establish a steering committee to develop a cadre of instructors knowledgeable in remote sensing, and,

2. Develop a proposal for Summer training in remote sensing. (Seven indicated interest in attending a training session: John Longshore, Robert Rasmussen, Don Garlick, Hal Jackson, Tom MacFarlane, Dennis Anderson, Mary Lauck.)

   The participants also agreed that any steering committee should be headed by Drs. Lawrence Fox and Robert Hodgson.

   Also, the participants felt that the steering committee should work with the goals and objectives of both the Dec. 3rd and January 7th workshops. These goals and objectives are to be prioritized for future interaction with the university.

FACULTY REMOTE SENSING WORKSHOP

December 3, 1977 and January 7, 1978

Forestry Building, Room 203

PROGRAM

8:30 - 9:00	COFFEE / REGISTRATION	
9:00	WELCOME *Dr. Sharon K. Ferrett, Dean of Continuing Education*	
	INTRODUCTION	What is the NASA Grant? *Donna Hankins, Project Director* *Dr. Robert Rasmussen, Biology*
9:30 - 10:30	REMOTE SENSING TECHNOLOGY - The Products, The Approach	*Dr. Lawrence Fox, Forestry, Project Technical Coordinator* Industrial Applications and Implications for the University *COMARC, Inc., San Francisco and Denver*
10:30 - 10:45	DISCUSSION	
10:45 - 11:00	COFFEE BREAK	
11:00 - 12:00	REMOTE SENSING TECHNOLOGY - The Process	
12·00 - 1:00	LUNCH (Provided)	
1:00- - 2:00	POTENTIALS FOR PROGRAM and/or EDUCATIONAL DEVELOPMENTS	A. Undergraduate - *Dr. Lawrence Fox, Forestry* B. Graduate - *Dr. Robert Hodgson, Oceanography* C. Facilities Development
2:00 - 2:30	FACULTY DEVELOPMENT, OTHER POSSIBILITIES	*Dr. Hal Jackson, Geography* *Donna Hankins, Project Director*
2:30 - 3:30	SPECIAL INTEREST GROUP DISCUSSION	
3:30 - 4:00	SUMMARY	

'lease detach and return to Office of Continuing Education, HSU:

/__/ I would like to attend the December 3, 1977 program.

/__/ I would like to attend the January 7, 1978 program.

/__/ I cannot attend either program but am interested in learning about the Remote Sensing Grant and what it can do for faculty/students at HSU.

66

____

Name *Department*

THE CENTER FOR COMMUNITY DEVELOPMENT
HUMBOLDT STATE UNIVERSITY
Graves Bldg , (No. 25) Graves Annex Bldg. (No 30)
ARCATA, CALIFORNIA 95521 — TEL. (707) 826-3731 (2,3)
REMOTE SENSING AND TECHNOLOGY TRANSFER PROJECT

TOM PARSONS
Director

August 21, 1978
LF-78-ProfWorkshp

Dear Donna :

I wanted to remind you that the Humboldt State Professors Workshop is beginning Wednesday, September 6, and will continue through Friday, September 15. The first three day session (Sept. 6-8) will be held at the HSU Forestry Building, Room 203, from 9 am until 4 pm each day.

The second phase of the training will take place at NASA Ames Research Center, near Menlo Park, Calif. Joe Webster is making travel arrangements for you to depart Arcata, Hughes Air West on Sunday, Sept. 10 at 3:45pm, and return on Friday, Sept. 15, at 2:25 pm. Tickets and Per Diem travel advances will be supplied during the HSU Session. State Vehicles will be made available for use while at NASA Ames.

If for any reason you would like to make different arrangements for travel to and from the Bay area, or if your plans for attending the session have changed, please contact Joe Webster at 826-3731.

I enclose a final version of the agenda for your information. Don't forget your homework!!

Best Regards,

Larry

Lawrence Fox III
Forestry

LF:jlw

ORIGINAL PAGE IS
OF POOR QUALITY

AGENDA

HSU PROFESSORS WORKSHOP

SEPTEMBER 6 - 11, 1978

Humboldt State University - Forestry Rm. 203

Wednesday - Sept. 6	**ASPECTS OF ORBITAL REMOTE SENSING**
9:00-9:15 am	Introduction
9:15-10:15	Comparitive evaluation of orbital imagery. Increased dependence on radiance when resolution is poor. Effects of poor resolution on radiance values for homogeneous and heterogeneous scenes.
10:15-10:30	BREAK
10:30-11:30	Overall comparison, U-2 to Landsat. Pixel concepts, radiance values into grey levels, line printer maps.
11:30-1:00	LUNCH
1:00-2:30	Comparitive Exercise - Spectral Reflectance Curves, Two Channel Maps
2:30-4:00	Theory of Digital Processing, Supervised vs Unsupervised, Guided Clustering
Thursday - Sept. 7	**STATISTICAL THEORY**
9:00-12:00 am	Statistical rules for Landsat classification, maximum likelihood and clustering algorithms.
12:00-1:30	LUNCH
1:30-4:00	Advanced Sampling Theory, multi-level schemes.

Friday - Sept. 8	COMPLETE REVIEW OF EDITOR SOFTWARE
9:00-11:00 am	Choose Training Sites
11:00-12:00	Enter Data into Computer
12:00-1:00	LUNCH
1:00-3:00	Cluster on Training Sites Run Unsupervised
3:00-4:00	Pool and Merge Statistics Final Classification

NASA Ames Research Center - Applications Branch

Monday - Sept. 11	VISUAL INTERPRETATION OF LANDSAT WITH FIELD EXERCISE
9:00-5:00	
Tuesday - Sept. 12	INTRODUCTION TO COMPUTER SYSTEMS
9:00-12:00 am	IDIMS demonstration: + Water Search + Humboldt Bay
12:00-1:30	LUNCH
1:30-5:00	Digitizing Exercise
Wednesday - Sept. 13	LANDSAT CLASSIFICATION
9:00-10:30 am	Computer orientation
10:30-5:00	Concurrent working sessions: ARPANET & IDIMS
7:00-10:00(evening)	Classify Humboldt Bay Scene

Thursday - Sept. 14	CONCLUDING THOUGHTS
9:00-10.30 am	Map Legend Information vs Spectral Classes
10:30-11:30	NASA Thermal Programs Is D.D Stress degree Day
11:30-4:00	Free time to visit with NASA scientists
4:00-5:30	How to get Started
7:30-10:00(evening)	Open for free play with IDIMS and EDITOR
Friday - Sept. 15	VISIT TO US GEOLOGICAL SURVEY
9:00-12:00	USGS programs at Menlo Park, Geography Program and NCIC
12:00	Depart for Airport

WORKSHOP-EVALUATION FORM

In order to effectively evaluate our presentations, we need your input. Please fill out this form and return it to Joe Webster, Center for Community Development.
Please rate the following workshop presentation on a scale from excellent (4) to poor (0). Your comments would be appreciated.

H.S. U. Program

COMPARATIVE EVALUATION OF ORBITAL IMAGERY:

Perceived Value to you. ____
Quality of Instruction. ____
(Speed, clarity, enthusiasm)
Comments ____
____
____

OVERALL COMPARISON, U-2 TO LANDSAT:

Perceived Value to you. ____
Quality of Instruction. ____
Comments ____
____
____

COMPARATIVE EXERCISE:

Perceived Value to you. ____
Quality of Exercise. ____
Comments ____
____
____

THEORY OF DIGITAL PROCESSING:

Perceived Value to you. ____
Quality of Instruction. ____
Comments ____
____
____

STATISCAL THEORY:

Perceived Value to you. _____
Quality of Instruction. _____
Comments____

REVIEW OF EDITOR SOFTWARE & COMPUTER PROCESSING:

Perceived Value to you. _____
Quality of Instruction. _____
Comments____

OVERALL COMMENTS:

NASA Ames Program	Perceived Value	Quality of Instruction
1. Visual interpretation of Landsat with field exercise.	_____	_____
2. Introduction to computer systems.	_____	_____
3. Landsat classification.	_____	_____
4. Concluding thoughts.	_____	_____
5. Visit to US Geological survey.	_____	_____

Comments:

If you have any other comments concerning the Program, please send them to Joe Webster, Center for Community Development.

CHARTING THE FUTURE

During the next academic year, one of my grant responsibilities will be to assist and encourage development of integrated, multidisciplinary curriculum in remote sensing at H.S.U. This workshop is designed not only for specific training for you but also for the purpose of stimulting an interest among the participants in beginning to integrate what is learned into the various teaching areas.

It would be very helpful if, during the workshop you would consider the following questions.

After you have completed the workshop, I would appreciate it if you will answer the questions and return the questionnaire to me before October 1, 1978.

1. Do you recognize areas where Remote Sensing Technology could be integrated into your teaching field? In your department In your school

Could you itemize two such areas.

2. Could the areas of integration be simply augmentation of existing courses? If so, please elaborate.

a. at undergraduate level?

b. at graduate level?

3. Could the areas of integration also be new courses? If so, please describe what these new courses should be?

a. at undergraduate level?

b. at graduate level?

4. What do you think student prerequisites should be?

a. in 2A, B.

b. in 3A, B

5. What are the implications for staffing/faculty that you would see in the above questions?

a. in #1

b. in #2

c. in #3

6. What do you think the equipment requirements should be in any of the above questions.

a. in #1

b. in #2

c. in #3

7. Would you be willing to consider being an instructor at future community workshops, involving federal, state or local agencies and entities?

AGENDA

, NASA-AMES WORKSHOP

Monday, September 11

8·00 - 8:30	Introduction		Sue Norman
all day	Visual interpretation of Landsat with field experience		Chuck Poulton Bill Likens

Tuesday, September 12

8:30 - 10:15	Applications orientation and techniques		Sue Norman Dave Peterson
10:15 - 10:30	BREAK		
10·30 - 12·30	Applications demonstration		
	Group I:	Humboldt Bay (IDIMS) Raw Data Classified data Band ratioing	Camie Butler
	Group II.	San Francisco scene Digitizing lecture	Dave Morris
12·30 - 1 30	LUNCH		
1:30 - 3·30	Applications demonstration (con't)		
	Group II:	Humboldt Bay (IDIMS)	Camie Butler
	Group I:	Digitizing	Dave Morris
3·30 - 3 45	BREAK		
3:45 - 8.00	IDIMS Workshop with Humboldt Bay data (supervised technique)		Charlotte Henry

Wednesday, September 13

8 30 - 10·00	Computer orientation lecture		Sue Norman Bill Likens
10·00 - 10 15	BREAK		

Wednesday, September 13 (con't)

10:15 - 12:15	Lab exercise (S.F. scene) with U-2 photography and line printer output (Lab exercise to be developed by Norman/Poulton/Likens/Henry/week of September 4)	Chuck Poulton Bill Likens Sue Norman
12:15 - 1:15	LUNCH	
1:15 - 2:45	Computer workshop (S.F. scene) Group I: EDITOR Group II: IDIMS	Buzz Slye Bill Likens Charlotte Henry
2:45 - 3:00	BREAK	
3:00 - 4:45	Group I: IDIMS Group II: EDITOR	Buzz Slye Bill Likens Charlotte Henry
4:45 - 8:00	IDIMS Humboldt Bay analysis (continue supervised technique)	Charlotte Henry Sue Norman

Thursday, September 14

8:30 - 10:00	Map legend information vs. spectral classes	Chuck Poulton
10:00 - 11:00	Thermal Remote Sensing	
11:00 - 3:00	Free time to visit with NASA scientists	by appointment with NASA personnel
3:00 - 5:00	"How to get started" & Wrap-up Session	Chuck Poulton
5:00 - 8:00	IDIMS session with Humboldt Bay	Charlotte Henry

Friday, September 15 VISIT TO GEOLOGICAL SURVEY.

9:00 - 12:00	USGS programs at Menlo Park, Geography Program and NCIC	
12:00	Depart for Airport	

COMPARATIVE EXERCISE

SPECTRAL REFLECTANCE CURVES - TWO CHANNEL MAPS

This exercise is designed to enable you to more fully understand the relationship between spectral information and land cover information. Spectral data is collected by Landsat and is correlated with land cover. It is important to understand this correlation so that one can learn to make predictions as to what land cover type is represented by a particular spectral class. This understanding is especially important when one is faced with the job of "assigning" land cover categories to a number of spectral classes produced by the computer.

In this exercise you are to choose 6 land cover types that you are especially interested in. For example, if you are interested in geography, you might choose Urban-Commercial, Urban-Residential, Agricultural, etc. If you are interested in coastal processes, you might choose, Bare Sand, Dune Vegetation, Surf, shallow water, deep water, etc.

The detail of your categories depends on the ability of Landsat to distinguish differences. Also, you will find that the satellite is often too sensitive. That is, more than one spectral class is contained within one land cover class. Your general class, Agricultural, might include spectral categories for mature crops, green crops, irrigated pasture, non-irrigated pasture, etc. Therefore, you should allow your categories to "evolve" as you progress through the exercise.

STEP 1 CHOOSE LAND COVER TYPES

By looking at the line printer (LP) maps displayed around the room, you should choose about six land cover classes of interest to you. Each land cover class should be represented by about 3 geographical areas which are "pure" examples of your land cover class.

These are your "training sites" or "training areas." Estimate the mean radiance level (in each channel) for each training area using the LP map symbol key provided below:

Approx.[1] Radiance Value	Radiance Grey Level	Symbol	Explanation
0-3	1		overstruck $,W,B
4-8	2		overstruck $,W
9-14	3		overstruck D,B
15-20	4	W	Cap W
21-26	5	G	Cap G
27-32	6	%	Percent sign
33-38	7	;	semi-colon
39-44	8	'	apostrophe
45-128	9		blank

[1] These radiance values vary from one channel to another but follow this same pattern. The radiance values are assigned on the basis of the pixel value distribution of the scene(the histogram) in one particular channel. Level nine is always a large interval since very few data points occur above 40 or 50 in any one channel.

Suppose that you choose a representative area of conifer forest. By viewing each channel(all 4 LP maps) you should come up with 4 numbers or grey levels, one for each channel. They could look like this:

Channel	Grey Level	Symbol
1 (green)	2	▓
2 (red)	1	■
3 (IR)	3	B
4 (IR)	3	B

You will have to do some estimation here since your training areas will probably not be completely homogeneous. That is, only one symbol or grey level per cover class in each channel. You are to choose one grey level or symbol which represents the entire training site. That is, the most commonly occurring symbol. After you are done, you may have different grey levels for training sites which should be the same. That is, several training sites, which all represent the same land cover type, may have different grey levels. Record all grey levels since this is the spectral variability you will "have to live with."

STEP 2 PLOT A TWO CHANNEL MAP

Plot the representative grey levels of each of your training sites on the two channel map provided. You are to plot the channel 2 level and channel 4 level only.

Channel 1 is often highly correlated with channel 2, and channel 3 with 4. Therefore, one can assess the majority of the spectral differentiation possible by viewing a two dimensional plot of 2 and 4. Plot all of your training sites and encircle those belonging to the same land cover type.

WHAT LAND COVER TYPES ARE ASSOCIATED WITH WHAT REGIONS OF SPECTRAL SPACE ON THE TWO CHANNEL MAP?

To answer the above, make a list of your categories and indicate the location of each cover class on the two channel map. For example, conifer forest is usually found in the lower left corner.

STEP 3 PLOT LANDSAT SPECTRAL COUNTS

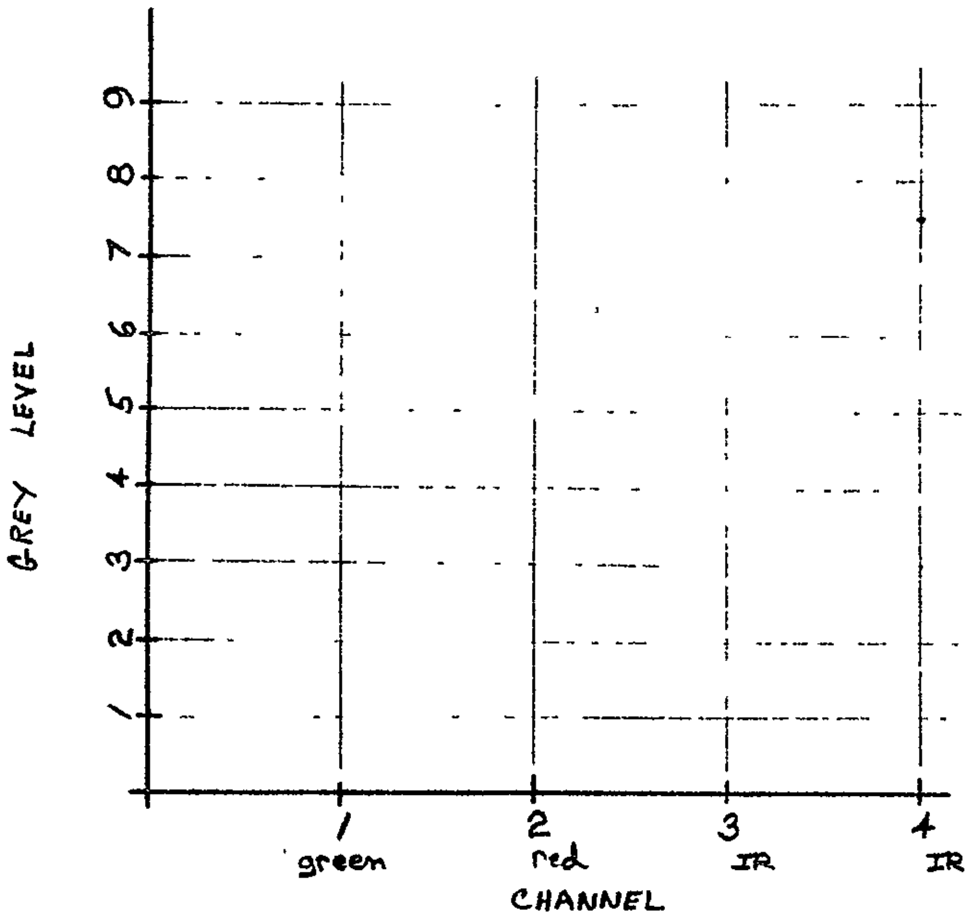
Plot the representative grey level of each of your training sites on the 4 channel spectral count charts provided. (Things are usually readable if you plot about 3 land cover types per axis.) The plot will be very similar to spectral reflectance curves with which you are already familiar. The major difference between spectral count curves and reflectance curves is the drop in radiance value between channel 3 and channel 4. This is a function of the dtector in the spacecraft and not the light reflectance of the land cover category. The data in channel 4 is compressed into 64 levels instead of 128 like the other channels.

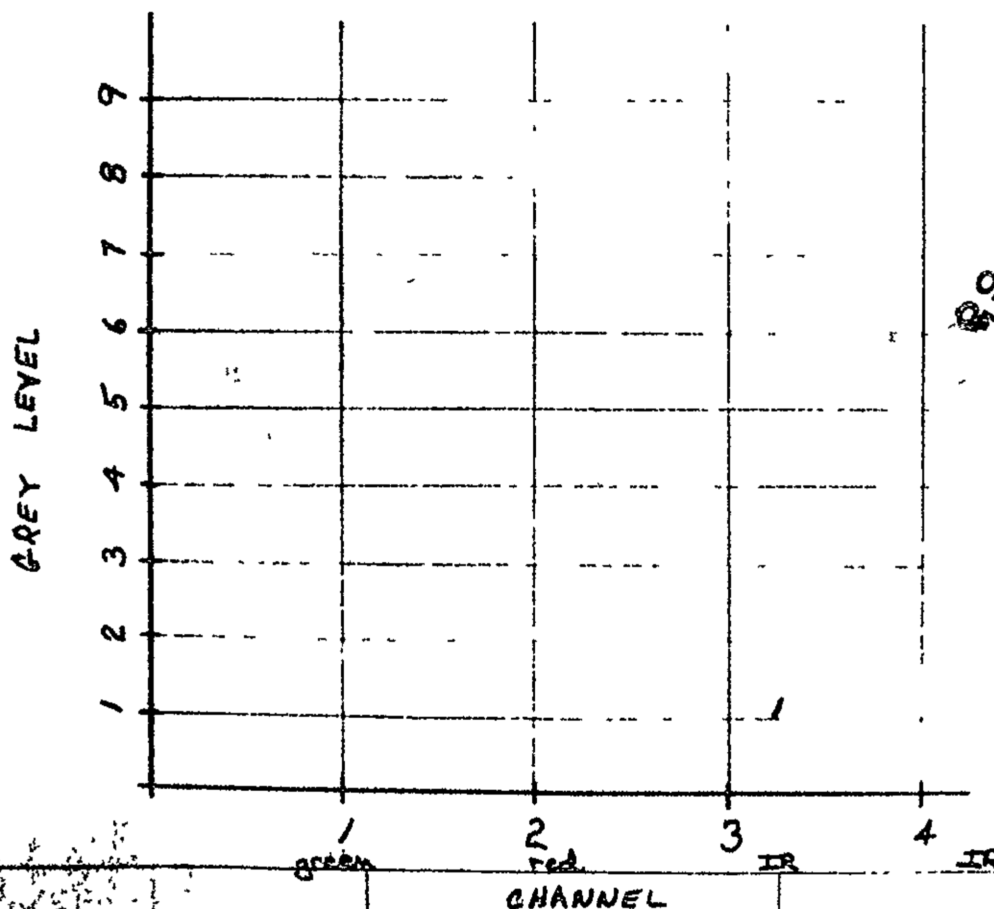
WHAT LAND COVER TYPES ARE ASSOCIATED WITH WHAT SPECTRAL CURVE SHAPES OR POSITIONS?

WHAT DOES THIS CHARACTERISTIC CURVE SHAPE MEAN? 

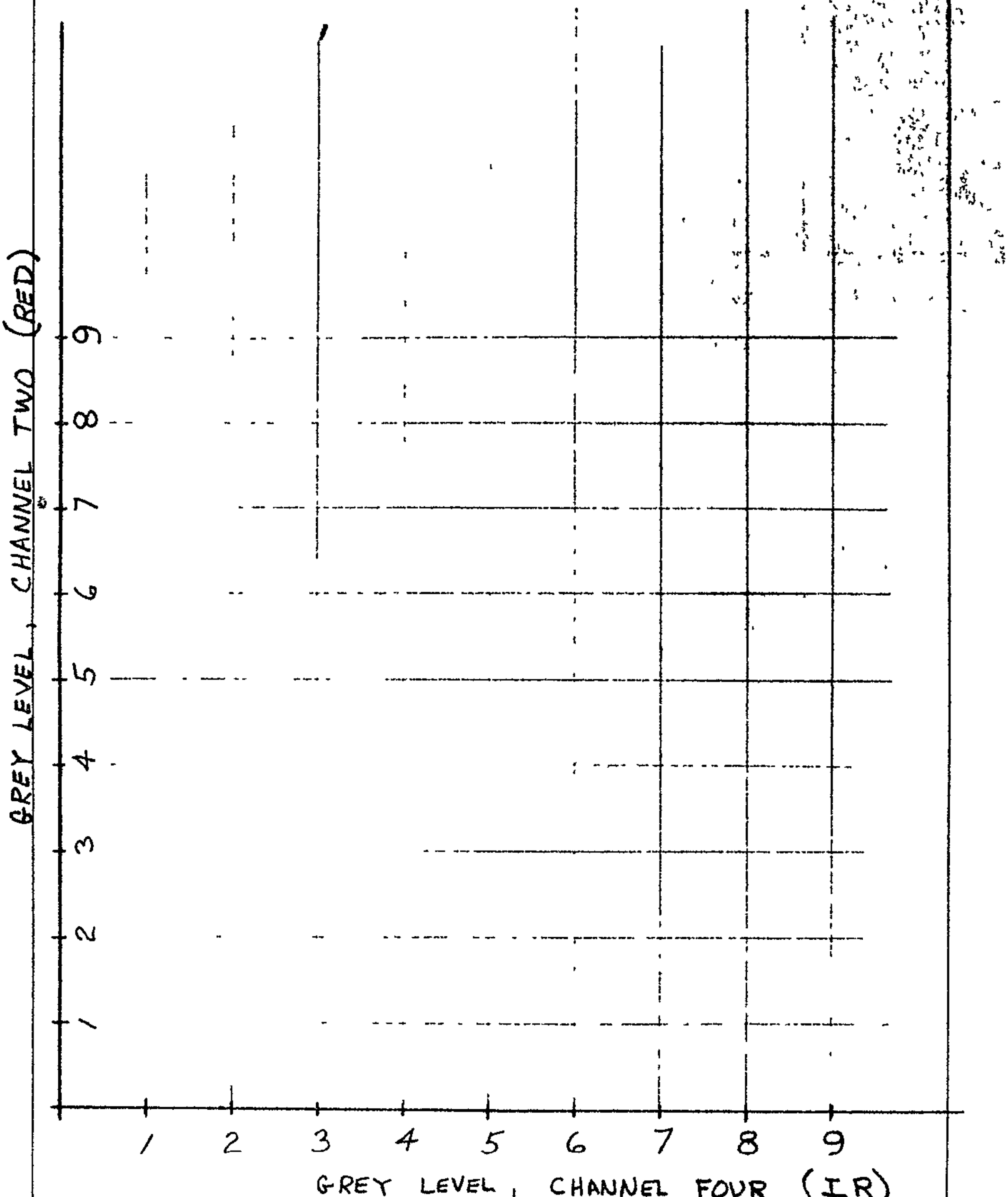
WHAT OTHER CHARACTERISTIC SHAPES CAN YOU DEFINE?

LANDSAT SPECTRAL COUNTS





LANDSAT TWO CHANNEL MAP



Excerpt From Sabins, 'Remote Sensing Principles and Interpretation'

7
DIGITAL IMAGE PROCESSING

Remote-sensor images are acquired by technologically advanced systems, but are typically interpreted through the use of simple classical techniques that have progressed little beyond the stereoscopes and magnifiers employed in the early days of aerial photography interpretation. Examination of original images with the unaided eye often constitutes the crucial interpretation phase for data produced by imaging systems that represent millions of dollars in research and development. The photographic methods for contrast enhancement and color compositing described in Chapter 4 enable the interpreter to extract more information from the original images but they lack the advantages of digital techniques. The principal advantages of digital processing methods are their versatility, repeatability, and the preservation of the original data precision.

Computer processing of images is not new; the medical, agricultural, and military intelligence communities have employed digital image processing for a number of years. Geographers were among the first scientists to recognize the potential of digital methods for investigating patterns of land use. The availability of digital multispectral images from the Landsat program accelerated the development and application of digital image processing in the mid-1970s. This field will see major advances in technology and application in the future. Some of the requirements for applying digital image processing to oil exploration have been summarized by Sabins (1974).

IMAGE STRUCTURE

Any image may be thought of as consisting of tiny equal areas, or picture elements, arranged in regular lines and columns. The position of any picture element, or *pixel*, is determined by an X and Y coordinate system with the origin at the upper left corner in the case of Landsat images. The brightness of each pixel has a numerical value ranging from zero for black to some higher number for white. Any image can now be described in strictly numerical terms on a three-coordinate system with X and Y locating each pixel and Z giving the gray-scale intensity value. An image may be recorded originally in this digital format, as in the case of Landsat. An image recorded initially on photographic film may be converted into numerical format by a process known as digitization.

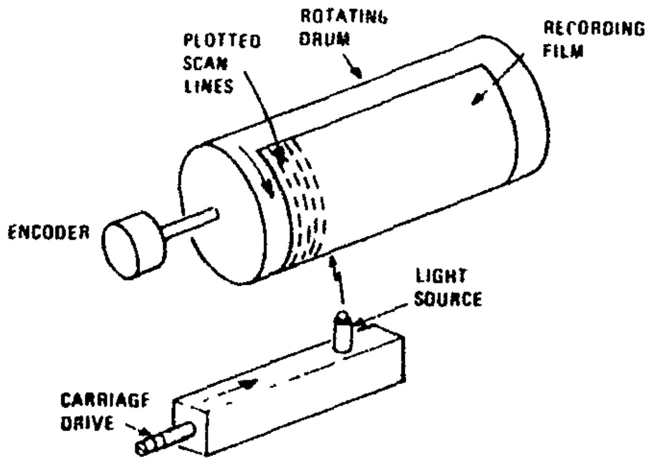


FIGURE 7 2
System for plotting an image from digital data From Bryant (1974 Figure 3)

Image Generation Procedure

Digital image data are converted into hardcopy images by film writers (Figure 7 2) that operate in reverse fashion to digitizers. Recording film is mounted on a drum With each rotation a scan line is exposed on the film by a light source the intensity of which is modulated by the digital values of the pixels Upon completion of each scan line the carriage advances the light source to commence the next line The exposed film is developed to produce a transparency from which prints and enlargements are made

Flying-spot plotters produce an image with an electron beam that sweeps across the fixed film in a raster pattern This system is also employed to display images on a television screen, which enables the interpreter to view the processed image in real time rather than waiting for the processed data to be plotted onto film, developed and printed

Landsat Image Format

A major advantage of Landsat multispectral scanner MSS imagery is that it is directly recorded as digital numbers on magnetic tape This greatly facilitates the application of computer processing programs The oscillating mirror of the MSS sweeps across the terrain at a right angle to the orbit path (Figure 7 3) and records data only during the eastbound sweep The 185-km long scan lines form a continuous strip of imagery that is subdivided into lots of 2,340 scan lines to produce individual Landsat scenes (Figure 7 3) The ground resolution cell of each detector is a 79 by 79 m square Solar energy reflected from this ground area onto the detector generates a response that varies in amplitude proportionally with the intensity of the reflected energy.

A segment of a scan line showing the variation

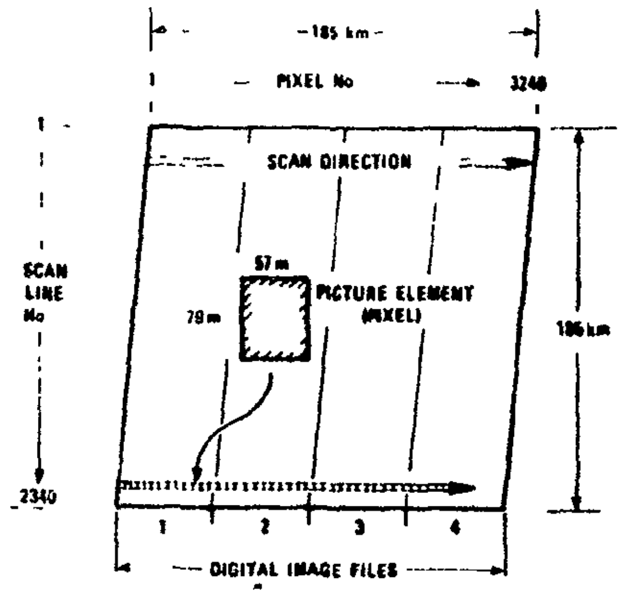


FIGURE 7 3
Reference system of scan lines and pixels for Landsat MSS image Note location of digital image files on computer compatible tapes

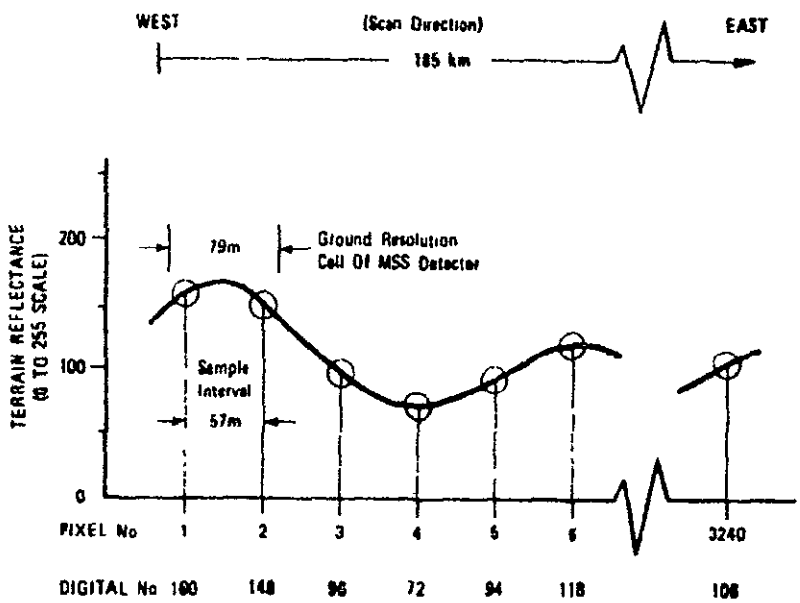


FIGURE 7 4
Plot of terrain reflectance along a Landsat scan line The 79-m ground resolution cell of each MSS detector produces a reflectance curve that is sampled at intervals of 57 m to generate the digital number for each pixel

85

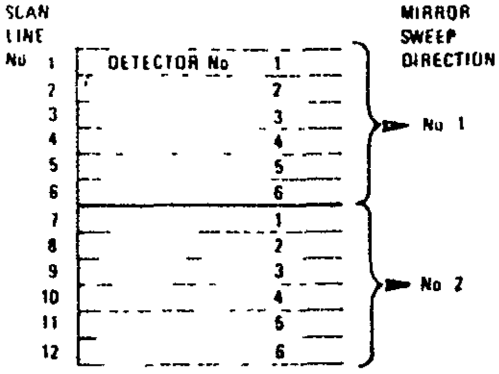


FIGURE 7 5
Detail of detector array for Landsat MSS

in terrain reflectance is illustrated in Figure 7 4 together with the 79 m dimension of the ground resolution cell The curve showing reflectance as a function of distance along the scan line is called an *analog display* because the data are shown in directly measurable quantities Analog displays differ from *digital displays* which record information in numerical form Analog data are converted into digital data by sampling the analog display at regular intervals and recording the value at each sample point in digital form Onboard the Landsat vehicle the analog signals are sampled at 57 m intervals and converted into digital data that are transmitted to earth receiving stations As shown in Figure 7 4 the sampling of a scan line produces 3 240 pixels each with a corresponding digital number that represents the reflectance The analog signal could be sampled at any interval the 1 4 ratio of the ground resolution cell to the sample interval (79 m 57 m 1 4) was determined theoretically and experimentally to be adequate for representing the analog signal A higher ratio (smaller sample interval) would not appreciably improve the digital data a lower ratio would degrade the quality of the digital data This information was provided through the courtesy of Virginia Norwood of the Space and Communications Group of Hughes Aircraft Company which designed and built the MSS Spatial resolution of the image is ultimately determined by the 79 by 79 m dimensions of the ground resolution cell the smaller sample interval does not alter this relationship

Each sweep of the scanner mirror reflects light onto an array of six detectors for each of the spectral bands simultaneously producing the array of six scan lines shown in Figure 7 5 The advantage of this design is that the number of mirror sweeps and the mirror scan velocity are reduced by a factor of six A disadvantage is that the response of one detector may differ from that of the other five, causing every sixth scan line to be brighter or darker Digital methods for correcting this image defect, which is called *sixth-line banding*, are discussed later in this chapter Each of the four bands of a Landsat image contains 7 6 10^6 pixels (2 340 scan lines, each with 3 240 pixels) that are recorded on computer compatible tapes (CCTs) A tape contains four data files each of which represents a strip that is 46-km wide in the east-west direction and 185-km long in the north-south direction (Figure 7 3) Each data file contains the brightness values for the four spectral bands interleaved A fifth file contains data for the image annotation The CCTs are available from the EROS Data Center at a cost of \$200 per Landsat scene Prior to processing, most laboratories convert the CCT data into four new files each containing a single spectral band for the entire scene Details of the tape format are described by Thomas (1975) and in the "Landsat Data Users Handbook by NASA (1976)

The brightness values for bands 4 5 and 6 are recorded on CCTs using a seven-bit scale (0 to 127), band 7 is recorded on a six-bit scale (0 to 63) Prior to processing some digital systems multiply these values by two or four to produce a consistent eight-bit scale for all four bands. In addition to consistency between MSS bands, the uniform eight-bit format minimizes errors introduced by rounding of decimal values. To reduce computer processing time and core usage, integer (whole number) mathematics are used wherever possible. Decimal values are integer truncated (rounded) to the nearest integer. In six-bit format (0 to 63) computed values of 8.6 and 9.3 are both truncated to an integer value of 9; in eight-bit (0 to 255) format the equivalent of a six-bit value of 8.6 is represented by 34 and 9.3 by 37 (4 × 8.6 = 34.4; 4 × 9.3 = 37.2).

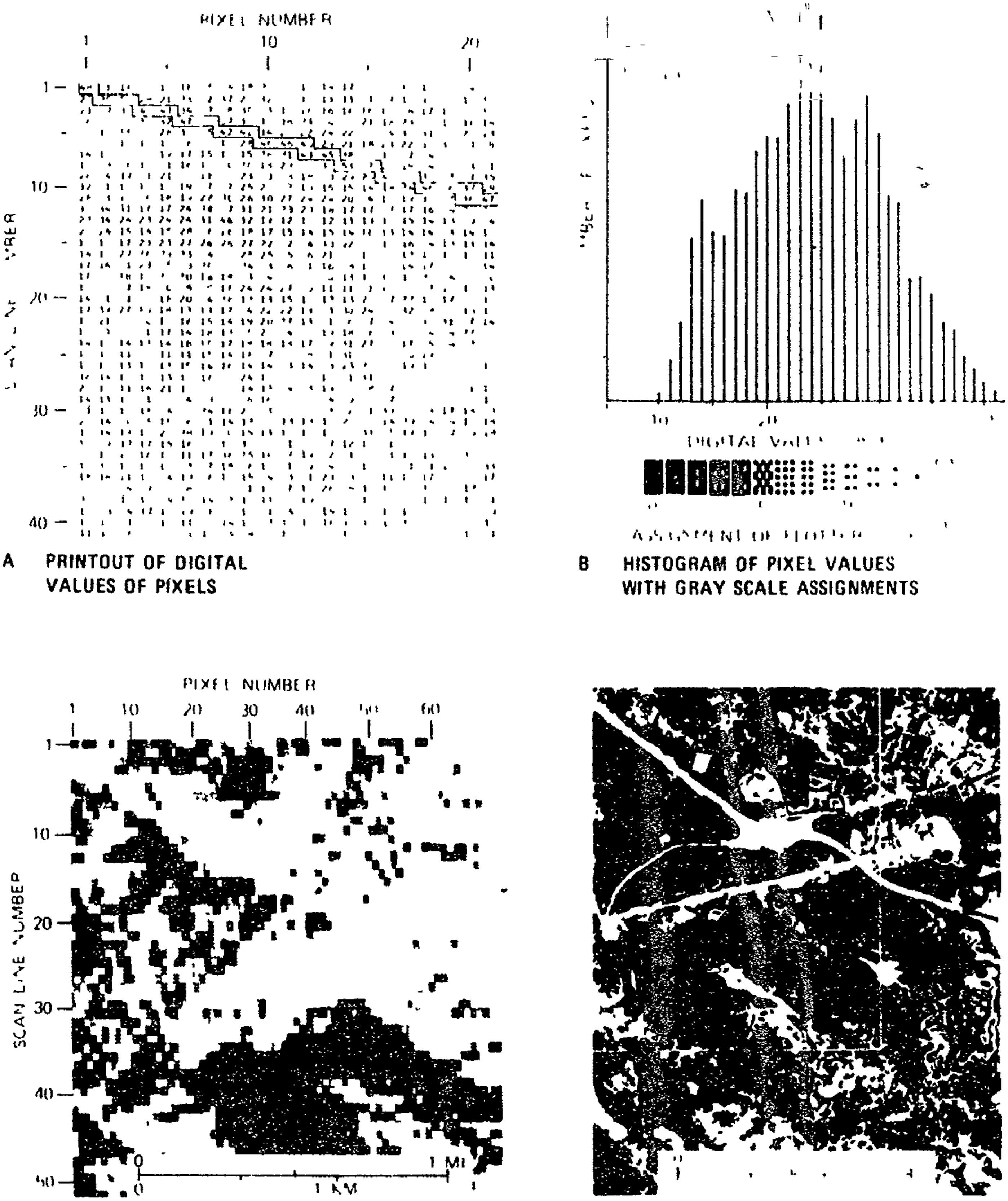
The computer printout of pixel values in Figure 7.6A represents a small subarea of a Landsat image. The upper left corner (pixel 1, line 1) coincides with the northwest corner of the image. Each pixel is represented by a *digital number* (DN) with higher values indicating higher reflectance of the terrain. The outlined diagonal strip of pixels with higher values represents the highly reflective concrete surface of the 280 Freeway, which is also shown in the aerial photograph (Figure 7.6D). The printout is geometrically distorted because two spaces are required for each pixel, plus a blank space between adjacent pixels.

The initial step in converting the numerical pixel array into an image is to determine the statistical distribution of the brightness values of the pixels. This is shown in the histogram (Figure 7.6B) where the number of pixels corresponding to each DN value are plotted. The histogram was prepared for a larger scene of which the pixel array in Figure 7.6A is only a subarea, hence the histogram does not exactly match the pixel population of the subarea. The 14 gray-scale symbols of the line printer are then assigned to specific ranges of DN values, with the darker symbols for the lower DNs. Values of 10 and less are plotted with a solid black symbol; values of 35 and higher are plotted with solid white. The 12 intermediate gray-scale symbols are each assigned to two digital values as shown along the abscissa of the histogram in Figure 7.6B. The resulting image is shown in Figure 7.6C, where each pixel is represented by a gray-scale symbol. This portion of the Landsat band 5 image covers the northwest corner of the aerial photograph (Figure 7.6D). The dark tones on the image and photograph are vegetation; the light tones are the 280 Freeway, the Stanford Linear Accelerator, and residential areas. These examples also provide a comparison of spatial resolution of the Landsat image with an aerial photograph at an original scale of 1:60,000.

The MSS image data telemetered from Landsat are recorded on magnetic tape at the Fairbanks, Goldstone, and Goddard receiving stations. At Goddard Space Flight Center (GSFC) these tapes are used to produce a 70-mm archival film for each of the four bands. A second-generation film is sent to EROS Data Center (EDC) which reproduces the images for sale to the public. As described in Chapter 4, this procedure is scheduled for change in late 1977. Most EDC images reproduced from the GSFC films are satisfactory for many users; the major problem has been the high density and low contrast of 70-mm black-and-white positive transparencies, which was discussed in Chapter 4. In addition, some images have defects that can be corrected or improved by digitally processing the data from the CCTs.

IMAGE PROCESSING SYSTEMS

Digital systems for processing Landsat and other images have been developed by a number of universities, government facilities, and commercial organizations. One of these is the Video Image Communication and Retrieval (VICAR) system developed at the Jet Propulsion Laboratory (JPL), which is a NASA facility at Pasadena, California, operated by the California Institute of Technology. Details of the VICAR system are given by Goetz and others (1975). The Laboratory for Applications of Remote Sensing (LARS) at Purdue University has developed the LARS System (LARSYS) for



A PRINTOUT OF DIGITAL VALUES OF PIXELS

B HISTOGRAM OF PIXEL VALUES WITH GRAY SCALE ASSIGNMENTS

C GRAY SCALE DISPLAY

D AERIAL PHOTOGRAPH

FIGURE 7 6
Digital structure of Landsat image showing conversion of pixel values to gray scale display. Area is Palo Alto, California, on Landsat 1525 18145 [illegible]
Data courtesy R. J. P. Lyon, Stanford University

tures and then assigns pixels to categories based on similar signatures The two general types of classification schemes are supervised and unsupervised classification which have the following distinctions

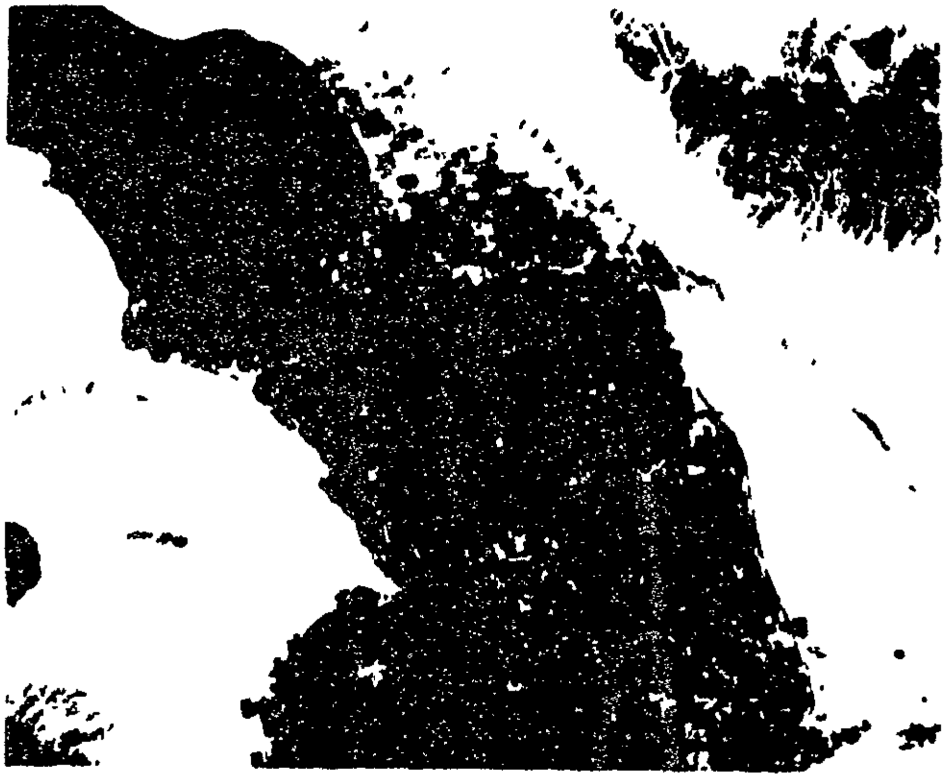
1 *Supervised classification* uses independent information to define training data that are used to establish classification categories The independent information may be spectral reflectance data for the classification categories as in the following example for the Salton Sea and Imperial Valley Another source of information is knowledge of the location of areas within the image that typify each of the desired classification categories Such localities are known as training areas and are illustrated by the Pakistan example in Chapter 8 Supervised classification is the most widely used of the two classification schemes

2 *Unsupervised classification* uses only the statistical properties of the image data as a basis for classification The computer alone defines the classification categories This method is potentially useful for classifying images where the analyst has no independent information about the scene

Each of these classification schemes can be further subdivided into (1) *parametric classification* which assumes certain mathematical models and (2) *nonparametric classification*, which assumes no model restraints Because nonparametric classification makes the fewest assumptions it is considered to be the more powerful technique

A simplified example of supervised multispectral classification uses a Landsat image covering the Salton Sea Imperial Valley, and adjacent mountains and desert areas of southern California (Figure 7 24A) Training data are the generalized reflectance spectra for water agriculture, desert and mountains shown in Figure 7 25A The data points are plotted at the center of the spectral range of each of the four Landsat MSS bands In Figure 7 25B the reflectance spectra are plotted in three-dimensional space using the values for bands 4, 5, and 6 as coordinates The solid dots are loci of the spectra shown in Figure 7 25A Bayesian classification methods assume that the samples belonging to each class form a *cluster* within the decision space The clusters shown diagrammatically in Figure 7 25B represent ellipsoids whose dimensions are a function of the scatter of the samples within the cluster The surface of the ellipsoid forms a decision boundary within which all points of that class occur

During classification of a Landsat CCT the computer retrieves the four spectral values for each pixel and determines the position of the pixel in the classification space Should the pixel fall within one of the decision boundaries, or clusters it is classified accordingly Pixels that do not fall within a decision boundary are considered *unclassified* In practice, the computer calculates the mathematical probability that a pixel belongs to a class if the probability exceeds a designated threshold the pixel is assigned to that class Applying this method to the digital data of the Salton Sea and Imperial Valley scene produces the classification map of Figure 7 24B In this example the volume of data is reduced by averaging groups of adjacent pixels and using this value in classification Note that the unclassified category indicated by the blank pattern, occurs at the boundaries between classes where the pixels include more than one terrain type The computer classification of Landsat data actually operates in four-dimensional space using all four spectral bands but this cannot be shown on the three-dimensional plot of Figure 7 25B



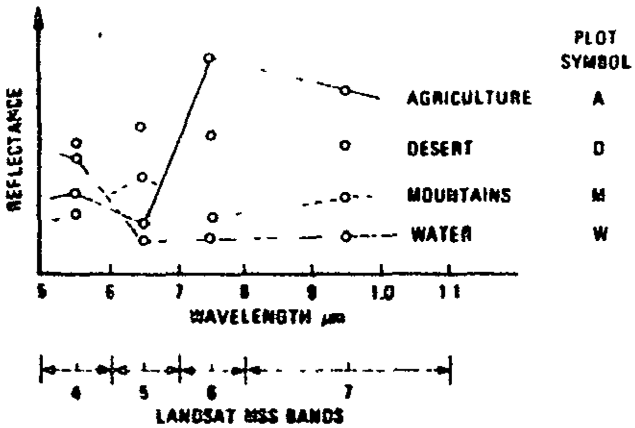
A LANDSAT 1052 17495 BAND 5 ACQUIRED SEPTEMBER 13, 1972

0 20 MI

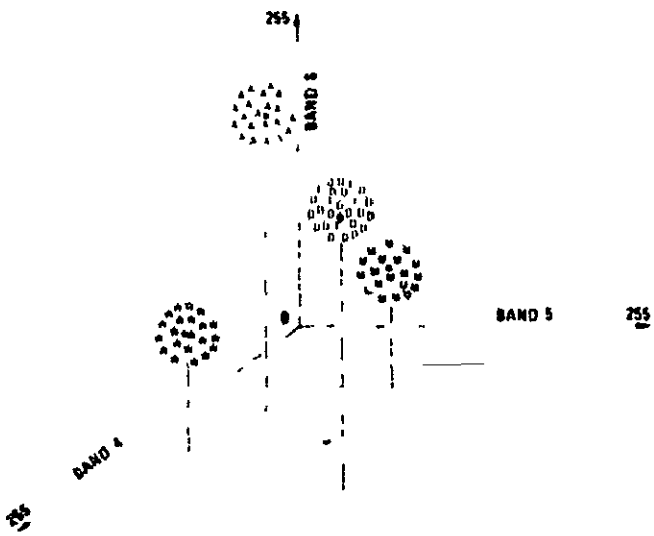
0 20 KM

B CLASSIFICATION USING THE CLUSTER DIAGRAM OF FIGURE 7 25B
A AGRICULTURE D DESERT M MOUNTAINS W WATER, BLANK UNCLASSIFIED

FIGURE 7 24
Digital classification of Landst CCT data for Salton Sea and Imperial Valley California



A SPECTRAL REFLECTANCE CURVES FOR MAJOR TERRAIN TYPES



B. THREE-DIMENSIONAL CLUSTER DIAGRAM FOR CLASSIFICATION

FIGURE 7 25
Spectral reflectance curves and cluster diagram for Landsat CCT data of Salton Sea and Imperial Valley

For demonstration purposes the classification categories mapped in Figure 7 24B are very broad For detailed work the individual crop types in the Imperial Valley can be classified by their spectral properties The different types of rock and detrital material in the mountains and desert can be separated in similar fashion The example from Pakistan in Chapter 8 illustrates the use of more restricted classification categories to recognize potential copper deposits

REMOTE SENSING WORKSHOP
1978

PROCESSING SEQUENCE - LANDSAT DIGITAL ANALYSIS

1 Interpret resource types - Identify on photo's, maps 7½min. and Line Printer maps.

2. Select training areas on Line Printer map - up to 3 resource types, 2-3 training fields for each - try to make these resource types as different as possible.

3. Clip the Windows

4. Create histograms of the windows and determine the number of clusters.

5. Cluster the Windows

6. Create STAT files

7. Create Multi-Window files

8. Pool and Merge STATS

9. Create final STATS

10. Classify your windows with the final STATS

11. Print windows with classification

12. Use Photos and Field Experience to varify the classification. May determine errors of Commission and Ommission?

EDITOR COMMANDS
(for Selected Computer Steps Needing Further Explanation)

NOTE Operator Commands in CAPITAL letters or underlined

STEP

3) Clip a Window.

!SUB
Input Window File= WIN.HAYFORK 77
(Old Version)
2!COORDINATES
*NORTH, WEST, SOUTH, EAST CR
* " " " " "
* (same for each window of that resource type)
* CR(twice)
2!WRITE -(this writes the file)
2!QUIT - (repeat steps for each resource type)

4) Print a Window:

!PRINT
Which output Device? T = (terminal)
Input window file=the resource window you clipped
See the list of window Y = (yes)
Which window displayed (-1 = all) -1
Which channel (1thru4) 2 (and the next run 4)
Global or local Histogram G
Display Histogram (Y,N or only) ONLY

5) Cluster a Window:

!RAW
2!MODIFY
Disk File Name = ENTER YOUR CLIPPED WINDOW
3!Number of clusters = WHATEVER YOU CHOOSE
3!QUIT
2!CLUSTER
3!ORDINARY - (for ordinary clustering)
Input Stat file N
Input window file=the name you entered above
Minimum number of cat after merging= the NUMBER of CLUSTERS
What % convergence 100
Max number of iterations 20
Want to see Stats Y
(it will then give you the separability matrix , means and variances)
Do you wish to save Y
Output Stat File= NAME IT
Create a CAT window file N
(repeat for each of your resource types)

STEP

7) Create a multi-Window File

!SUB WINDOW
Input window file=WIN.HAYFORK 77
2! COORDINATES
* NORTH, WEST, SOUTH, EAST, CR
* " " " " "
* (same for each window of that resource type)
* CR(twice)
2!WRITE (and name it_
2!QUIT

8) Pool and Merge Stats:

!RAW
2!STAT file editing
Input Stat file= enter your 1st State file
#WRITE
Low cat, High cat = 1 space?whatever number of clusters you have
#OPEN
Input Stat file= enter your next Stat file
#WRITE
Low and high cat = repeat for this file
#GENERATE
Output Stat file= give these two windows a new name
Do you wish to continue Y
Input Stat file= enter the same as above
#Separability Swain Fu
Mark a threshold Y
Threshold Value= .45
#VARIANCE
#MEANS
#NUMBER OF CLUSTERS
#WRITE (Whatever categories you want to save - in order)
#POOL (Whatever categories you want to save - in order)
**(Repeat until you have written and pooled all of the categories)
#GENERATE
Output Stat file= name the file
(repeat for the next Stat file)
#OPEN
Input Stat file = put the name of the file you just created
#WRITE
(Continue on in this manner)

']I'

10) Classify

```
 !RAW
2!CLASSIFY
 Number of Channels= 4
3!Gaussian
 Enter R for restart CR
 Enter Increment to save CR
 Input Stat file = enter final Stat  file
 Input Window file = enter Multi-Window fi
 Enter increment to Print CR
 Cat Window file = enter Cat Window file f
                   for Multi-window file
2!QUIT
```

r.d

GLOSSARY

active system
A remote sensing system which transmits its own electromagnetic emanations at an object(s) and then records the energy reflected or refracted back to the sensor.

band
A group of wavelengths of light producing one color or convenient group of wavelengths, such as near-infrared.

CALSCAN
The set of classification programs for aircraft and satellite data handling and analysis developed by the Center for Remote Sensing Unit at the University of California at Berkeley.

color composite
Color composite of channels (bands) of multispectral data. Generally, composites are third- or fourth-generation images, compared to first-generation composites produced from computer-compatible tapes using a film recorder.

computer-compatible tapes
Tapes containing digital LANDSAT data. These tapes are standard 19-cm (7 1/2-in.) wide magnetic tapes in 9-track or 7-track format. Four tapes are required for the four-band multispectral digital data corresponding to one LANDSAT scene.

concatenation
aerial images in a series which have been geometrically rectified (often stretched) and edgematched to form a continuous, planimetric vertical mosaic.

edge effect
As used here, refers to slight mis-registration between two or more channels which produces computer misclassification.

emissivity
A ratio relating the amount of energy given off by an object to the amount given off by a "black body" at the same temperature, and normally expressed as a real positive number between 0 and 1.

enhancement
Refers to various processes and techniques designed to render optical densities on imagery more susceptible to interpretation.

ground truth

(Field verification) Definition of Earth surface conditions through direct measurements or visual inspections for calibration or evaluation of remote sensing observations from satellites or aircraft.

hectare

Ha, a metric unit of area equal to 10,000 m^2 or 2.47 acres.

imagery

The visual representation of energy recorded by remote sensing instruments.

KANDIDATS

The set of computer classification programs for aircraft and satellite data handling and analysis developed at the Remote Sensing Laboratory, University of Kansas.

LANDSAT-1 (ERTS-1) scene

Collection of the image data on one nominal framing area (185 km^2) of the Earth's surface. The scene includes all data from each spectral band of each sensor.

LARYSYS

The set of classification programs for aircraft and satellite data handling and analysis developed at the Laboratory for the Applications of Remote Sensing, Purdue University.

line scanning

The use of a facsimile device, such as an intensity-modulated cathode-ray tube, which produces an image by viewing and recording a scene a line at a time.

maximum likelihood ratio

Maximum likelihood ratio in remote sensing is a probability decision rule for classifying a target from multispectral data. Two types of errors are possible: failure to classify the target correctly and mis-classification of background as the target. In its simplest form the likelihood ratio is P_t/P_b. This expression compares the probability (P) of an unknown spectral measurement being classified as target (t) to the probability of an unknown spectral measurement being classified as background (b). When $P_t/P_b \geq 1$, the formula decides t; and when P $P_t/P_b < 1$, it decides b. Probability density functions are computed from spectral samples, often called training samples. As the number of training samples increases, the mathematical computations of the maximum likelihood ratio increase in complexity. As a result, digital computer analysis is required. The analysis is called automatic data processing of multispectral remotely sensed data or automatic spectral pattern recognition of multispectral remotely sensed data.

Multispectral scanner system, sometimes called the multispectral scanner. The MSS usually refers to the LANDSAT operational scanning system.

multiband
A study using more than one band.

multispectral scanner spectral bands
The division of the visible and near infrared portions of the electromagnetic spectrum into discrete segments. The bands employed in LANDSAT-1 are as follows:

MSS channel	LANDSAT-1 band	Wavelength, nm	Color
1	4	500-600	green
2	5	600-700	red
3	6	700-800	reflective
4	7	800-1100	infrared

optical system
A system whose basic function involves the recording of a scene by the use of lenses and/or prisms.

passive system
A remote sensing system which images energy emitted or reflected as radiation from a given scene. The system produces, transmits, and records no energy of its own.

permeability
Capacity of a material to transmit fluids.

photographic system
A remote sensing system which produces an image directly on a film emulsion from reflected electromagnetic radiation of wavelengths in the visible and near-infrared portions of the EM spectrum.

pixel
Picture resolution element, or one instantaneous field of view recorded by the multispectral scanning system. A LANDSAT pixel is about 0.44 hectare (1.09 acres). One LANDSAT frame contains about 7.36×10^6 pixels, each described by four radiance values.

polarization
The act or process of filtering energy in such a way that the vibrations are restricted to a single plane. Unpolarized energy vibrated in all directions perpendicular to the propagating source.

radiance
Measure of the radiant energy emitted by a radiator in a given direction.

raster
A geometric pattern followed by the sending element of a detector system, or by the electron beam of a television transmitter or receiver.

rectification
The process of coverting a tilted or oblique image to the plane of the vertical.

reflectance
Ratio of the radiance of the energy reflected from a body to that incident upon it. The reflectance of a surface depends on the type of surface, the wavelength of the illumination, and viewing angles.

reflectance infrared
Radiation in the spectral region from 0.7 to 3.0 μ which is reflected as a result of illumination from natural sources. The portion of the infrared region which is imaged on infrared sensitive films extends only to about 1.5 μ ; longer wavelengths are recorded by detection.

resolution
The ability of a remote sensing system to distinguish signals that are close to each other spatially, temporally, or spectrally.

sensor
An instrument used to detect and/or record electromagnetic energy associated with an environmental phenomenon.

signature
A set of spectral, tonal, or spatial characteristics of a classification serving to identify a feature by remote sensing.

spectral response
Spectral radiance of an object sensed at the satellite and recorded by the multispectral scanner

supervised classification
Classification procedure in which data of known classes are used to establish the decision logic from which unknown data sets (e.g., land uses) are assigned to different classes.

threshold
The boundary in spectral space beyond which a data point, pixel, has such a low probability of inclusion in a given class that the pixel is excluded from that class.

training field

The spatial sample of digital data of a known ground feature selected by the investigator. From the sample the spectral characteristics are computed for supervised multispectral classification of remotely sensed data. The statistics associated with training fields are often input to the maximum likelihood ratio computations to train the computer to discriminate between samples.

VICKERS

The set of classification programs for aircraft and satellite data handling and analysis developed at the California Institute of Technology, Jet Propulsion Laboratory (JPL).

visible

That portion of the electromagnetic spectrum between wavelengths of 400 to 700 millimicrons, which corresponds to the spectral response of the human eye.

wavelength

The distance between two successive crests or troughs of a wave at uniform frequency and oscillation, measured in the direction of the propagation of the wave. Wavelength equals velocity divided by frequency.

HUMBOLDT STATE UNIVERSITY Arcata, California 95521 (707) 826-3946

Department of Geography

DATE: November 29, 1978

TO: Joe Webster
Remote Sensing Project

FROM: Joe Leeper
Department of Geography

SUBJECT: HOW KNOWLEDGE AND MATERIAL FROM NASA WORKSHOP APPLIED

This quarter I have been able to sue a great deal of material and knowledge garnered during our September workshop. I have prepared a rather extensive slide collection, especially from the IDIMS screen and from various other imagery available at Moffett Field. A sample of its usage follows.

1) Geography 190 - Geography for Teachers. This class is composed of prospective teachers who have little if any prior knowledge of Remote Sensing or its applications. I prepared an illustrative lecture demonstrating samples of imagery and a handout listing the various addresses of imagery sources. In addition, I tried to discuss various teaching strategies involving the imagery. They were a most receptive audience and respresent a group who, if they use Remote Sensing, can reach a rather large audience.
2) Geography 5 - Economic Geography: Three different topics were used during the quarter (Petroleum Exploration, Land Use Types, and Land Use Planning) that had illustrated lectures using Remote Sensing as a tool. Several people will take the Remote Sensing class in the spring if it is offered as they were attracted by the techniques.
3) I have been invited to speak to our Cartography Club and demonstrate our Landsat work-up of Humboldt Bay. Larry has also talked to the Cartography Club this quarter so they will have been exposed to Remote Sensing more than once.
4) I have given several informal slide presentations to a variety of students, faculty, and townspeople. Most got off on the U-2 launch, but I have received several invitations to make formal presentations in the future and in early December I will be giving such a presentation to a civic group in Fortuna.

JSL:bh

Proposed Paper

The Use of Guided Clustering Techniques to Analyze Landsat Data for Mapping of Forest Land Condition in Northern California

by

Lawrence Fox III
and
Kenneth E. Mayer

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U.S. Fish and Wildlife Service
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INTRODUCTION

The U.S. Fish and Wildlife Service (USFWS) cooperated with Humboldt State University and the NASA, Ames Research Center (ARC), in using Landsat multispectral (MSS) data to inventory land condition and vegetation on the Hoopa Valley Indian Reservation. The USFWS is using this data in their continuing investigation of the declining anadromous fish population within the Klamath and Trinity rivers.

Landsat digital analysis was accomplished via a remote computer terminal at Humboldt State University. The terminal was linked by phone to several computer systems which were administered through the Institute for Advanced Computation (IAC), an associate of NASA, Ames Research Center. The use of the EDITOR software was critical to the success of this project. EDITOR is a series of interactive sub-routines which allow the analyst freedom in performing cluster analysis within specified training areas (guided clustering).

The purpose of this paper is to discuss the successful use of this analysis technique in defining the maximum number of spectral classes within any one land condition or vegetation cover category.

Description

Supervised and unsupervised classification techniques are the two commonly recognized approaches to multispectral classifications. These techniques have been used successfully in the past, although operational difficulties exist.

The supervised approach allows the analyst freedom in identifying training areas on the ground which represent specific resource categories. These areas are used to develop sets of multivariate statistics which contain means, variances and covariances. Statistics generated from these areas are then used to classify areas of unknown composition. A maximum likelihood classifier is a common algorithm used in this process. Difficulties often arise when variances are high (15-30) within a given training area. This is especially common when clustering is preformed on areas of natural vegetation. Areas such as agriculture are less likely to have confusion because of their consistent composition.

Given a constant Euclidean distance, statistical distances between classes are reduced when variances are high resulting in fewer unique spectral categories defined. Areas which appear to be single cover types on aerial photographs may consist of several spectral classes. The analyst is often forced to accept high variances if the area to be classified is extremely heterogeneous.

The unsupervised classification approach can alleviate this problem. In an unsupervised classification the analyst estimates a reasonable number of spectral classes that will be representative of the area. There is no attempt to define small, homogenous training areas. Multivarate clustering algorithms are used to assign pixels to the selected spectral classes. Separability or divergence statistics are evaluated to identify inseparable classes. This process may be repeated several times until the maximum number of spectral classes are defined. This technique assures minimum variance within any one spectral category. The unsupervised approach may cause several problems, however.

The analyst often has little concept of what each spectral class represents in terms of resource or land cover category. Since no training areas are defined, it becomes difficult to assign meaningful resource labels to individual or groups of spectral classes. Often the number of spectral classes defined is more than twice the number of land cover classes required for the inventory.

Guided or controlled clustering has recently been reported in the literature (Rohde, 1978) as a means of solving the problems generated from the unsupervised and supervised techniques. EDITOR is a software system that allows either a supervised or unsupervised approach. Through EDITOR it is possible to use these in conjuction creating guided clustering.

In our project, we approached the classification problem with a supervised strategy, using guided clustering. Training fields were defined for each vegetation category within the study area. Histograms were constructed from spectral information in each channel for the categories defined. A visual inspection of these histograms indicated the number of spectral categories present. Our training areas contained between three and six spectral classes. A minimum distance clustering algorithum was used to establish the spectral classes and separability statistics were calculated. A separability of 0.45 for any two or more classes required that the clustering process be repeated with fewer classes. Statistical modeling indicated 0.45 as the minimum separability needed to classify with an approximate 0.95 probability of correct classification (Card, pers. comm. 1978). The clustering process was repeated specifying more classes when any of the spectral classes possessed a high (10) variance. In this way a maximum number of spectral classes was assigned to each land cover category reducing class variance. This process was repeated for every vegetation cover category defined.

Since each clustering was completed independently, several spectral classes were inseparable (i.e., very similar statistically) when statistics from each vegetation cover category were merged together. The individual clusters were merged and edited to remove spectral confusion. Additional sets of spectral classes were merged until all vegetation cover categories had been included. Separability statistics were analyzed at each step. A class was always deleted when it conflicted (i.e., separability of less than 0.45), with two or more other classes. Two conflicting classes were pooled together creating a new class if the variances were reasonably low, less than ten; if the variances of one class was more than ten, it was deleted. The new class contained all of the pixels present in the two original classes prior to pooling.

The final spectral classes were merged with the unsupervised classes to include any spectral categories not present in the training areas. From this, it was possible to define a maximum number of low variance spectral classes for the entire Landsat scene. The classes were used to drive a maximum liklihood classification for all of the training areas. The classification was printed out in alphanumeric code at approximately 1:24,00 scale. The shape and location of each training area was preserved on this print out.

U-2, 1:32,500 color infrared photography was interpreted to determine the exact vegetation-cover or land condition at various points within each training area. This detailed photo-interpretation enabled us to assign meaningful vegetation cover labels to the spectral classes defined within the training fields by guided clustering. However, spectral classes still existed without resource labels, as some classes did not appear in the training areas. A window was selected from the Landsat scene that was representative of the study area and classified with the final statistics. The remaining un-named spectral categories were identified and labeled through further detailed interpretation of U-2 photographs.

Conclusion

Guided clustering was instrumental in defining all of the spectral variability present in the project area. The maximum number of separable spectral classes was defined insuring a minimum (10) variance per class through guided clustering.

References

Card, Don 1978, Personal Communication.

Rohde, W.G., 1978, Digital image analysis techniques required for natural resource inventories.

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American Indian Languages and Literature Program

Assistance to Northwest Indian Cemetery Protective Ass'n

Community Education Project

Humboldt Co Recreation Project

Indian Mainstream Industries Project

Indian Manpower Development Project (C E T A Title III Prime Sponsorship)

Kotim Een Karuk Ceremonial Society

Retired Senior Volunteer Program (Action - RSVP)

Senior Nutrition Project

Student AMA American Indian Health Project

Wood for Seniors Project

TRIP REPORT

APPLICATIONS ASSISTANCE FACILITY
NATIONAL SPACE TECHNOLOGY LABORATORIES
Bay St. Louis, Mississippi 39520

August 9 and 17, 1977

Submitted to the

National Aeronautics and Space Administration
Ames Research Center

By

Lawrence Fox III
Technical Coordinator

IN COOPERATION WITH CALIFORNIA'S NORTHWEST COUNTIES

TRIP REPORT

APPLICATIONS ASSISTANCE FACILITY

EROS PROGRAM

NATIONAL SPACE TECHNOLOGY LABORATORIES
Bay St. Louis, Mississippi 39520

August 9 and 17, 1977

I visited the EROS Applications Assistance Facility on two separate days in conjunction with my trip to the NASA Slidell training course. The first visit to EROS was as a member of the group being trained at Slidell. We received an orientation lecture and a tour of the facility.

The center assists a user in ordering NASA Satellite and Aircraft data by providing a direct link to the Sioux Falls computer and microfilm of Landsat, Manned Spacecraft and Aircraft imagery. One is able to obtain the EROS computer listing which results from a geographical computer search while at the center. The outcome of a search is usually printed within one hour. Microfilm readers are available for one to view the scenes of interest that are selected from the computer listing.

The Center also provided assistance in non-digital image interpretation. They have photo-interpretation equipment that is available for use free of charge. Anyone may sign-up to use the equipment for a reasonable period of time on site. The equipment is impressive including two Variscan enlargers, a rear projection 30X enlarger, a Zoom Transfer Scope, several light tables and B&L binocular viewers, an ISI image analyzer, and digitizing table. The director mentioned that their emphasis on photo-interpretation of U-2 photography and other high resolution data is in conflict with the NASA effort to push Landsat technology. The people at EROS simply prefer U-2 data and they come right out and say it. These "anti-Landsat" remarks were quickly followed with a fairly strong pitch for Landsat. The NASA aircraft program is down-played by stressing that aircraft data is only available for some areas and at limited times. They point out that Landsat covers every area within the U.S. on a 9 day cycle.

Another service of the center is education in remote sensing. One or two hour seminars are given free and a 3½ day training course is offered at $140 per student. This course was described as a hands-on workshop in photo-interpretation skills. It appeared from the examples available around the room that emphasis would be placed on interpreting high altitude color-infrared transparencies.

Finally, the center maintains their own library of full reports and microfiche. They will search literature in remote sensing and allow one to borrow the microfiche copies of the reports.

I returned to the Assistance Facility a second time to search the Sioux Falls computer for Landsat coverage in Northern California and to use their image analyzer. It was very helpful to see the output generated by my Sioux Falls data search immediately. Particularly important was knowing the number of accessions. When the search produced few entries, for example, I re-ran it with relaxed quality and cloud cover specifications.

Dr. Anthony Lewis, a professor at L.S.U., had brought some radar data to be interpreted as part of a geology study that he was involved in. We used an image analyzer manufactured by Interpretations Systems Incorporated and were not able to bring out the linear features, that are often important for geologic interpretation, any more effectively than we were by using a 30X

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Retired Senior Volunteer Program (Action - RSVP)

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Student AMA American Indian Health Project

Wood for Seniors Project

TRIP REPORT

NASA EARTH RESOURCES LABORATORY (ERL)
The Slidell Computer Complex
Slidell, Louisiana 70458

August 8 - 19, 1977

Submitted to the

National Aeronautics and Space Administration
Ames Research Center

By

Lawrence Fox III
Technical Coordinator

TRIP REPORT

NASA EARTH RESOURCES LABORATORY (ERL)
The Slidell Computer Complex
Slidell, Louisiana 70458

Lawrence Fox - August, 1977

INTRODUCTION:

I have attended an Earth Resources Training Course produced for Murray State University, Kentucky from August 8 through August 19 (2 weeks). The course was designed to provide classroom and "hands-on" experience to 5 faculty members from the College of Environmental Sciences, Murray State. I was able to gain a tremendous amount of experience in processing Landsat tapes. As a "member" of the group from Murray State I was also able to observe part of the technology transfer technique employed at ERL. I was able to talk extensively with NASA personnel and with the people from Murray to gain a solid picture of both sides of the technology transfer effort.

This report is divided into five sections -- Technology Transfer at ERL, The Kentucky Reaction, The ERL Computer System, The Training Course, and Lessons Learned for Northern California.

I. Technology Transfer at ERL

What is Transferred - The ERL Offer.

The effort at ERL is explicitly limited to transferring the techniques necessary to process Landsat digital data using a computer. The final product is a geographically referenced land use classification. The view of the management at ERL is that only Landsat should be considered and further, only the computer classification of Landsat digital tapes should be promoted. For example, a training course management decision*was made not to purchase an image display system (CRT) which is capable of storing and showing all four Landsat bands separately or any three in a color additive rendition. It was felt that this type of system would promote the photo-interpretation of Landsat Imagery rather than the statistical classification of Landsat digits. They decided to purchase a two channel version to limit enhancement capability.

Given the above limitations of the transfer effort, the basic ERL proposition is to provide software and training. A prospective transferee is first offered a training course (the one I attended) at Slidell followed by a period "at home" to collect ground truth. Finally a one week follow-on course is offered to process their own Landsat data. ERL did not pay for travel or per-diem, only tuition and supplies were provided free for Kentucky. ERL usually does not purchase CCT's for prospective trainees other than the Louisiana data processed in the first course.

ERL then suggests that a group purchase the hardware (computer and data input/output devices) necessary to process Landsat digital data. This requires a capital outlay by the transferee of between $100,000 and $200,000. No brand names are suggested as being superior in quality or are "recommended" by NASA. Any mini-computer system meeting the specifications provided by ERL may be purchased by the future user of the technology. ERL then offers to provide all of the software

*As reported by a Lockheed employee.

(computer programs) developed at Slidell to purchasers of the hardware system. Also, people from ERL offer to spend two weeks at the transferee's facility to "bring up" the system at no cost to the cooperator.

Even though ERL claims to give private industry equal opportunity, I feel they do a grave injustice to industry by supplying free software. The ERL approach may give equal opportunity to the manufactures of general purpose mini-computers but they virtually eliminate people like GE and Bendix from the market place. How does a specialized image processing system like the Image 100 have a chance priced at about $500,000 when the NASA, software subsidized mini-computer system is available at $200,000 tops?

How The Technology is Transferred

The method is still being reviewed and modified according to Bob Barlow,an ERL administrator. The process begins when the director makes a presentation to a group of decision makers in State Government. ERL offers to provide training and software if the State will establish a remote sensing center to carry on regional projects in cooperation with various State Agencies. The State is required to purchase a mini-computer hardware system or designate a university within the State or a State Agency to house the hardware system.

PNW type demonstration projects are also a part of the ERL program. For these, the Landsat data is processed by ERL (Lockheed). For example one ASVT going on while we were there seemed to be having the transfer process placed into it. The cooperating group was becoming more involved in the actual processing of data than I am used to seeing.

As is often the case, the scenario did not develop as planned in the State of Kentucky. People from Murray State University contacted ERL before ERL had made complete arrangements with Kentucky State Government. ERL allowed Murray to come for a two week training session and will allow them to return for another week to process their own data. However, that will be the limit of NASA high priority cooperation with Murray State until Murray becomes officially designated by The Kentucky State Government to be a State University Remote Sensing Center. When and if that happens, ERL will provide software and debugging efforts for Murray State, provided that the University can purchase the necessary hardware. Barlow made it clear to me that NASA can not recommend Murray to the State. It has to be the State's choice. Barlow did provide the Murray people with a list of key State people to contact however.

II. The Kentucky Reaction

The people being subjected to the transfer effort were amazingly receptive compared with my experience with people in Northern California. They quickly grasped the significance of large area coverage, repeat coverage, and computer assisted, image interpretation. In short, they really appreciated the advantages of Landsat. They also perceived the satellites limitations but did not let those dominate their evaluation. They were not as "resolution hungry" as the people I've been dealing with in Northern California. The Kentucky group included two geographers and two agronomists and it is likely that they do not have the resolution requirements of the natural resource managers we have been dealing with in Northern California.

Murray's reaction to the NASA strategy of working with a State Remote Sensing Center was also positive. A member of the Murray group mentioned that they would like to see two remote sensing centers develop within the State, however. One within their university to train and develop individuals in remote sensing and one within State Government to be production oriented toward the inventory needs of government agencies.

III. The ERL Computer System

The Hardware consists of an image processing system, computer and an output recording device. The image processing system contains a typewriter keyboard/CRT terminal so that a user may interact with the computer and a large 3 color CRT to display Landsat imagery.

The computer can be any small or large CPU equiped with a FORTRAN compiler. The output devices vary from simple digital plotters to color film recorders.

A large group of computer programmers (Lockheed people) are located at Slidell and they are constantly working on more effecient and otherwise improved programs with the NASA principle investigators there. All of their past, present and future efforts are offered as the software package from ERL.

Programming exists to do four major tasks. Landsat CCT's are reformatted and classified according to the maximum likelihood decision rule by the PATREC group of programs. The supervised technique is used and provision is being added for unsupervised classification. The data are then referenced to the U.T.M. projection by the GEOREF programs.

A body of programs exist to then input the Landsat classified data into a geographical data base with a minimum cell size of 40 acres. Finally, applications programs are available to compute acreage, estimate crop production, measure erosion hazard and calculate carrying capacity for deer.

The hardware and software systems are described in NASA Technical Report number TR R-467, "Low-Cost Data Analysis Systems for Processing Multispectral Scanner Data"by S.L. Whitley. The system we worked on at Slidell is configuration 4 (p. 27) in that report.

IV. The Training Course

The course began with a two day orientation to remote sensing and computer processing of scanner data. The "hands-on" experience of computer classification began on day 3 as we selected training fields on a CCT of the New Orleans area which had been reformatted but not de-striped Training field selection is a tedious and time consuming process taking two full days and we only defined five classes of land use. The classification was complete by day 6 and we continued to reduce the unclassified area and improve the classification during day 7. Day 8 was spent referencing the data to the UTM coordinate system. Days 9 and 10 were used to produce black and white plots of the classification and demonstrate the water search programs (new unsupervised techniques) and the data base programs.

Overall, the course was excellent because it had plenty of time for experiencing the system first hand. I just could not keep my fingers away from that keyboard and so acquired the name "Crator Fox", due to my uncanny ability to blow down the system in an incredibly short period of time. We were encouraged again and again to touch the keyboard and that no matter what, we could not hurt the machine.

Two major points of criticism however. We did not really have any ground truth to use for selecting our training samples. The people from Kentucky and I were not at all familiar with the area in sourthern Louisiana and we had no aerial photography to work with. I know that light tables and NASA aircraft transparencies were available because the NASA principal investigators were using them. Possibly they did not want us to see the superior resolution of aircraft data, just a guess. Barlow felt that mine was a valid criticism and said that more ground truth would be available in future courses.

Since the course was taught by electrical engineering/computer programming types, the theory of Statistical Classification was not at all covered adequately. My background in remote sensing includes a good understanding of multivariate classification techniques and so I was not very sensitive to the omission. Most of the others were completely lost, however, because multivariate discriminant analysis is not usually covered in standard university statistics courses.

V. Lessons Learned for Northern California

I will now be able to communicate and illustrate, using slides taken at Slidell, computer analysis of Landsat digital data. Also, I will be able to describe Landsat "at full resolution" since I have worked with the CRT display. My experience will enable me to build confidence in the Landsat system among potential cooperators since I am now very certain about what the fully computerized system can and cannot do.

Requiring the user to purchase a computer seems almost to transfer the technology by "force". For example, I could imagine a government agency continuing to use Landsat digital data after they have determined it will not do the best job for them. It may be difficult to admit that a $100,000 to $200,000 expenditure was a mistake. This could be the source of a poor NASA image. By this I do not mean to imply that the "NASA process it for you approach" is superior because here the technology is never really transferred. Somehow there needs to develop an atmosphere where future users could be "weaned" away from aircraft photography, onto automated Landsat processing and thereby allow them time to carefully consider a decision to invest in their own computer hardware.

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TOM PARSONS
Director

TRIP REPORT

EDUCATIONAL INSTITUTIONS, NASA FACILITIES, AND RESEARCH CENTERS INVOLVED WITH REMOTE SENSING throughout the United States

Summer 1977

Submitted to the

National Aeronautics and Space Administration
Ames Research Center

by

Robert T. Hodgson
Associate Professor, Oceanography

IN COOPERATION WITH CALIFORNIA'S NORTHWEST COUNTIES

TRIP REPORT

EDUCATIONAL INSTITUTIONS, NASA FACILITIES, AND RESEARCH CENTERS INVOLVED WITH REMOTE SENSING throughout the United States

Robert T. Hodgson - Summer 1977

INTRODUCTION:

During the summer months of 1977 I travelled 12,000 miles visiting 21 agencies to learn about remote sensing. Basically, my itinerary included visits to three types of organizations: educational institutions involved in the training of remote sensing, NASA facilities charged with implementing technology transfer programs, and research centers applying remote sensing technology to the marine environment.

Before embarking on this trip, I had established certain objectives for myself.* Briefly, they were:

1) to become acquainted with the oceanographic applications of remote sensing technology so that I could become effective as a technical liaison between NASA and local oceanographic-oriented projects,

2) to develop a course, or perhaps a curriculum, in remote sensing technology for undergraduate students of marine science, and

*Memorandum 3, 21 June 1977, from myself to the Director, NASA Remote Sensing and Technology Transfer Project, Center for Community Development, Humboldt State University.

3) to help plan and/or evaluate education programs and facilities being planned for the Western Regional Applications Assistance Program.

This report is divided into three parts. The first part reflects my thoughts on transferring the technology of remote sensing to the oceanographic community. The second part is a journal describing my activities this summer in chronological order. The third part contains an outline for a remote sensing course intended for the Western Regional Applications Assistance Program.

I feel the summer has been very rewarding. I am fortunate in having participated in the remote sensing short course at Purdue and in visiting various laboratories, agencies, and universities. I have obtained a better understanding of how remote sensing can be applied to marine science and hope that my experiences can be of value to the NASA Remote Sensing and Technology Transfer Project.

PART I - Technology Transfer of Remote Sensing to Oceanography

During this summer, I found that oceanographic applications of remote sensing technology fall into two classes: those in which the color of the ocean is important versus those in which it is not.

In the first case, some of the techniques developed for the analysis of multispectral images (Landsat) have been useful in oceanographic applications, such as in the analysis of chlorophyll distributions or in the monitoring of oil spills.

However, Seasat-A, a satellite dedicated to oceanic investigations, does not employ multispectral imaging optics. This suggests that microwave, non-imaging sensors might play the dominant role in oceanographic applications of the future. Perhaps the most obvious reason for the lack of optical sensors on Seasat-A is due to the amount of cloud cover normally present over the ocean coupled with the relatively short residence time of many oceanic phenomena. Virtually all Seasat-A sensors have all-weather capability.

I suspect, therefore, that a transition will occur in the nature of experiments associated with satellite oceanography. Until the Seasat Program is operational, investigators will continue to employ Landsat-type methodology. Later, the emphasis will probably be in the microwave region of the spectrum.

Of course, this presents a problem to potential users (and teachers) of oceanographic applications of remote sensing. They may need to become trained in two relatively new fields -- multivariate statistics applied to pattern recognition and classification, and the interaction of microwaves with the sea's surface. I recommend the oceanographic community first be trained in Landsat-type data analysis in order to appreciate some of the present applications of remote sensing technology. As future applications develop, using the microwave region of the spectrum, additional training will be necessary.

In designing a university curriculum to transfer remote sensing technology to students of marine science, a fundamental educational choice must be made -- to train or to educate. In certain technological areas, for example in the operation of a milling machine, the objective may be to train, i.e., to teach the solutions to a limited set of problems. (Many subject areas are not mutually exclusive. Consider the training, or education, of a physician, engineer, or auto mechanic.)

In choosing an approach that incorporates the technology of remote sensing into the study of marine science, I have opted for the latter position -- to educate. My choice is partly determined by my philosophy of undergraduate education and partly dictated by the state of remote sensing technology in oceanography, which is still in its infancy. Presently, I feel there is more to gain by teaching fundamentals, relying on the student to use new technology in his investigations of the ocean.

To develop a curriculum in remote sensing of the marine environment, I first listed a number of applications topics. By constructing a curriculum for each topic, some curricular areas, common to a number of applications, should emerge. These will represent the basis of a core course (or courses). Self-study units, or seminars, could be developed for the remaining topics.

As an example, here is a list of oceanographic topics in which remote sensing technology could be applied: sea state measurements, wave statistics, sea ice analysis, ocean current description, oil spill detection, surface temperature distribution, heat capacity measurements, chlorophyll distribution, fish or mammal distribution, ocean color distribution, wind speed measurements, tidal analysis, salinity distribution, and fishing fleet location (especially with respect to the 200-mile limit).

In order to illustrate the range of curricular subjects related to these application areas, I have chosen chlorophyll distribution as an example. The associated curriculum might include: basic optics of water, optics of phytoplankton, principles of ocean color analysis, characteristic vectors and principal axis transformations, Mueller's (NASA) and Smith's (Scripps) approach to color analysis, recent papers by Maul (NOAA), Morel (MIT) and Duntley (Scripps), multivariate statistics, acquisition of remotely sensed data, the LARSYS software system, physical versus physiological color, etc. This list is not complete, but does suggest how remote sensing technology might be applied to the analysis of chlorophyll distributions.

I have not completed the above exercise for all of the applications topics, but feel confident a core curriculum would include the general subject of optical oceanography, multivariate statistics, and microwave interaction with the sea's surface.

PART II - Journal

July 8 - EROS Data Center, Sioux Falls, South Dakota: Dinah De Kraai, Protocol Officer.

I spent the day at EROS learning about its general organization, facilities, and training programs. From my experiences, I feel accessing its data by mail would be difficult, especially if a browse file (microfilm duplicates of EROS data tapes and other imagery) was not available. Although EROS has produced slide-tape educational packages on subjects such as "how to order Landsat imagery", these cost about $50, are not widely distributed, and the information in them is not available in published form. In this respect, EROS has not made it easy for potential users to gain access to its data.

EROS offers two courses a year. The course lasts four weeks and costs $1500. (A trip to the Black Hills is included.) Occasionally they send people to teach short courses at UCLA. For government personnel, they teach a course in digital image processing at about $500 per week, and will provide a technician and an image processing machine, like the Image 100, for $100/hour.

Some educational materials are available gratis at the facility including the LARS minicourses and some similar units produced by EROS. A description and price list of these materials is appended to this report as are several other documents I obtained at the EROS facility.

July 8 - EROS Data Center: Gerry Moore, Hydrologist.

My discussion with Mr. Moore was related to oceanographic applications of remote sensing technology. Moore suggested the following references:

a) H. L. Yager, Kansas Geological Survey, Moore Hall, 1930 Avenue A Campus West, University of Kansas, Lawrence, KA 66045. He has written about a way to reduce the effect of sun angle on effective radiance by comparing the ratio of radiance at two wave-lengths.

b) Gary Glenn, Regional Research Center EROS, Denver Hydrology of Estuarine and Intertidal Environments, Mail Stop 413 Box 25046, Denver Federal Center, Lakewood, CO 80225 (303) 234-2320.

c) Dave Hubble on sediment export (same as above).

d) Marvin Goldbert and E. R. Weiner, Remote Sensing of Water Quality, U.S.G.S. Report on a Roman Laser Spectroscopy (no date).

e) Robert D. Watson, U.S.G.S. Flagstaff, William R. Hemphill, U.S.G.S. Washington, D.C. and Robert C. Bigelow, U.S.G.S. Denver. Fraunhoffer line documentation to determine fluorescence. Applicable to oil spills, lignin sulfinate from paper mills, and phosphate wastes in Florida.

f) D.H.P. Boland, U.S. Environmental Protection Agency, Corvallis, Ore. Publication on trophic classification. EPA-600/3-76-037 April 1976.

July 8 - EROS Data Center: Dr. Robert Reeves, Staff Scientiest.

I had a short discussion with Dr. Reeves over lunch, and he suggested I contact Gilbert Fraga of the State Water Resources Board in Sacramento. His interest is in coastal pollution.

July 11-15 - <u>Laboratory for Applications of Remote Sensing (LARS), Purdue University, West Lafayette, Indiana</u>.

I attended the LARS short-course at Purdue to gain a general familiarity with the technology of remote sensing. I had hoped the experience would allow me to transfer some of the techniques used at LARS to oceanographic problems. Considering the length of the course (one week), I feel it was successful. The following summarizes the major objectives of the course. As is always the case, however, there is room for improvement and I include some suggestions.

<u>Objectives</u>. The Purdue course appears to be tailored to potential users of remote sensing technology who are more likely to be in an administrative role rather than in a purely technical one. For example, the last lecture of the course is spent explaining how the attendees might develop their remote sensing programs by coordinating with LARS, i.e., via a contract.

The technical content of the course concerns the <u>numerical</u> analysis of Landsat data as compared to an image oriented analysis. The approach is to classify pixels by their spectral signature. This is done by creating an n-dimensional vector, which has components representing the reflectance of the image at several wavelengths, ${}_1$, ${}_2$...., ${}_n$. Multivariate statistics is used to determine the likelihood that a given pixel belongs to one of a given set of classes, such as water, corn, soy beans, or fruit, for example.

However, the course does not dwell on technical details. I would guess that most attendees leave with only a vague understanding of the statistical models which separate corn from soy beans. The objective is to give a basic understanding of how a four-dimensional vector is constructed from a spectral signature and how this "feature vector" can be associated with other similar vectors to define a class.

Methodology. The course is well organized. The syllabus is complete and the class progresses on schedule from one activity to another throughout each day. The course includes "core" material and a series of slide-tape minicourses tailored to the interests of each attendee. In addition, a few hours are set aside for individual conferences with LARS staff.

The core material consists of about five video-taped lectures on the mathematical and statistical techniques used to separate feature vectors into classes. The slide-tape minicourses cover topics such as the spectral reflectance characteristics of vegetation, etc. They are valuable in conveying terminology, facts, and elementary concepts common to the field of remote sensing.

The practical aspects of classifying information in a Landsat scene are handled through a series of workshops. This is a valuable part of the course, for all of the attendees gain an understanding of the strengths and limitations of the computer algorithms. Also the role of the analyst and the interaction between the analyst and the computer is made clear. By the end of the week, the attendees should be able to use the LARS computer algorithms (LARSYS) to classify their own Landsat scenes, perhaps with a little help from LARS personnel.

Seminars by LARS researchers were scheduled, but the speakers were out of town or unprepared.

An optional feature of the Purdue course is the "hands-on" experience. The hands-on experience is intended to simulate a situation in which one would have access to a remote terminal -- connected to the LARS computer. (The third evening is spent making colored polaroid prints from the digital printout.)

__Suggested Improvements__. The following suggestions are meant to be constructive. I am sure the LARS staff has adjusted the structure and content of the course often. However, from my perspective several improvements could be made:

1) First, the academic pace of the course is quite slow. There is virtually no serious study during the week, nor time for it if the hands-on option is elected. There are no reading lists nor problems to be solved. The course could be improved vastly if the attitude was more scholarly.

2) The backbone of the theoretical part of the course is the set of lectures by Landgrebe and Swain. Rather than being scattered throughout the course, I would prefer to see this material lumped together (not necessarily at the beginning of the course) with pre-reading, video tapes, post-reading (individual), and group problem-solving sessions, followed by a "live" appearance by Landgrebe and Swain. This could easily occupy two days.

3) The lecture notes of Landgrebe and Swain need to be expanded, and the associated reference material should be made available.

4) Studying the LARS Information Note 110474, which is sent to the attendees before they arrive at Purdue, was quite useful. I would add a problem set on elementary statistics illustrating the definitions of mean, variance, and the covariance matrix.

5) I would delete the evening hands-on option as it was not an effective use of time. It is difficult to learn how to access the LARSYS system in two evenings. Also, the LARSYS documentation is not up to date and the two of us who elected this option gained little confidence in being able to interact on-line with the computer. However, about 30 per cent of the time is spent analyzing the computer print-outs. This reinforced the daytime

material and was a valuable component of the course. It should be incorporated into the regularly scheduled activity periods.

6) Reading for the next day should be encouraged.

7) While the workshop is a valuable part of the course, the tempo should be increased.

Conclusion. In the week spent at LARS, I obtained a good understanding of the LARS approach to classifying Landsat imagery. I learned to appreciate the importance of the analyst's interaction with the LARSYS algorithms and left with a desire to learn more about the basis of those algorithms. In short, the course was a success, but from an academic perspective, I feel there is still room for improvement.

July 18-19 - Space Science and Engineering Center, University of Wisconsin, Madison: Dr. Thomas Haig, Executive Director and J. T. Young, Meteorologist.

I visited the Space Science and Engineering Center, University of Wisconsin in Madison to learn about the McIDAS system. McIDAS stands for Man Computer Interactive Data Acquisition System. Presently the system's outstanding feature is its speed in acquisition and interaction. In the future, the system may also have greater analysis capability.

The McIDAS system provides an interesting comparison with the LARS system at Purdue. McIDAS offers almost immediate data acquisition from geostationary satellites, and enhancement of dynamic features at the touch of finger. The system acquires visible and thermal I.R. imagery of the earth's disk within five minutes of the satellite's transmission (every 1/2 hour). A series of images can be sequenced on the television screen to observe shifting cloud patterns, etc. The LARS system, by comparison, offers a static display. Its major feature is the ability to handle a large amount of data and apply statistical algorithms to classify ground elements by their spectral signatures.

Since the geostationary satellite also relays meteorological observations from many ground stations, McIDAS displays and synthesizes these data. For example, pressure and temperature contours are depicted as well as surface-wind streamlines.

McIDAS has one disadvantage, however. The system stores data from the geostationary satellite only if someone wants the data (and is willing to pay for it). The data are not automatically archived like Landsat images.

A training seminar illustrating McIDAS's capabilities, sponsored by NSF, was conducted at the University of Wisconsin in June and was attended by many professors of meteorology throughout the U.S. Another training session is scheduled for July. These are the only formal training sessions devoted to the McIDAS system.

July 23-25: Department of Geography and Anthropology, Louisiana State University, Baton Rouge: Dr. Anthony Lewis, Professor.

Dr. Lewis and I discussed his approach to teaching remote sensing technology. Lewis's courses are primarily geared toward air photo interpretation or image analysis as contrasted to numerical or digital processing of images. His introductory course includes a healthy dose of technical photography, such as use of filters, darkroom experience, and stereo photographs, etc. As a term project, each student must report on an application or process of remote sensing. In advanced courses, Lewis introduces radar imagery, his specialty.

Dr. Lewis supplied me with a number of student reports, pertinent bibliographies, copies of his publications, and course outlines. The outlines are appended to this report.

July 26 - Institute of Marine Resources, Louisiana State University, Baton Rouge: Dr. Oscar Huh, Oceanographer and Dr. Larry Rouse, Physicist.

I visited the Institute of Marine Resources to learn how they are using remote sensing technology as applied to oceanography. Principally, they are using sequential NOAA 5 satellite data to describe the onset of winter cooling in the Gulf of Mexico.

They have assembled a medium-speed, interactive computer system with a 24-bit, gray-scale plotter. This hardware is used to enhance the infrared emittance distributions over the Gulf of Mexico. Huh is philosophically against using color enhancement in his work, and said the one-to-one correspondence between infrared emittance and gray scale is superior to linking emittance to a variety of colors.

July 28 - EROS Applications Assistance Facility, Bay St. Louis, Mississippi: Frank Beatty, Director.

This facility is dedicated to providing service to users of remotely sensed data.

They offer:

1) short courses (usually 3½ days, cost is $140) to train people how to acquire data and use image enhancement equipment at the Bay St. Louis Facility,
2) free use of facility - optical planimeter, optical drafting, table for magnifying data film, etc.,
3) a good library (which contains an extensive collection of course notes from various sources),
4) color enhancement instruments (optical, not computerized),
5) a browse file of Landsat data, and
6) EROS slide-casette modules plus some of the LARS slide-casette modules.

The principal resource they lack is a computer system to perform numerical processing of Landsat tapes.

July 28 - Naval Ocean Research and Development Activity (NORDA), Bay St. Louis, Mississippi: Dr. Paul Laviolette, Oceanographer.

I visited NORDA to talk with Paul Laviolette. (I first met him in 1972 when he presented a paper on oceanographic applications of remote sensing.) Because of the recent reorganization of the Naval Oceanographic Office, much of Laviolette's effort has been spent settingup his laboratory at Bay St. Louis. He is currently working on an (ADP) unit which can receive images directly from the NOAA satellite. Although the resolution is degraded, the real-time capability in the field is useful for conducting oceanographic experiments.

July 28 - NORDA, Bay St. Louis, Mississippi: Ron Holyer, Oceanographer, and John Guagliardo, Research Chemist.

Ron Holyer is working with Dr. R. Bernstein at Scripps on an oceanographic experiment near Cape Mendocino. There is a good chance that NORDA can fund HSU to collect some ground-truth data. Also, Holyer provided me with a set of specifications for a digital image analysis system (appended to this report) which I thought might be of use to NASA.

John Guagliardo is interested in measuring vertical profiles of temperature within the ocean by using a laser source. I don't understand the mechanics of this, but he provided me with some pertinent publications.

July 29 - Earth Resources Laboratory, NASA, Slidell Louisiana: Bob Barlow.

I had planned to meet with Roy Estes of this facility, however he was involved in an auto accident the previous night. Consequently, I only received a short tour of the facility by Barlow. However, ERL appeared to have an established technology transfer program, and since Larry Fox was planning to participate in the program within a few weeks, I did not press Barlow for a more extensive tour.

August 2-3 - Physical Oceanography Laboratory, Atlantic Oceanographic and Meteorological Laboratories, NOAA, Miami, Florida: Dr. George Maul, Oceanographer.

Dr. Maul's research interest has been in computer enhancement of Landsat images to reveal various oceanographic phenomena. He has devoted some effort toward mapping the Gulf Stream. Accurate location of this oceanic current has saved shipping companies considerable revenue.

Maul has taught a graduate course in remote sensing at the University of Miami, and he gave me a copy of his syllabus (appended to this report). In contrast to Lewis's course, Maul's approach is quite mathematical -- he begins with the equation for an oscillating dipole!

August 8 - NASA Headquarters, Washington, D.C.: Don Montgomery.

I went to NASA headquarters to discuss the Seasat program with Don Montgomery. We talked about the overall organization of the Seasat program which reflects the needs of several user communities -- governmental agencies, academic research institution and private industry. Because of the various affiliations of the experimental teams, the project is funded by a variety of separate agencies.

One of the unusual features of the Seasat program is the participation of private industry. They have outlined several experimental objectives:

1) Better routing of ships to optimize routes based on sea state and

currents, and to optimize routes for temperature sensitive cargos, e.g. oil cannot be pumped if it is too cold, so ship-time is wasted in port while heating the cargo.

2) Better environmental prediction for oil exploration in potentially hazardous environments (Alaska). A consortium of six oil companies has contracted to obtain a wave spectra model for Gulf of Alaska and a real-time forecast ability.

3) Monitoring of ice pressure ridges for ice breaker design and routing.

4) Monitoring ice berg movements.

5) Predicting annual goose inventory by obtaining environmental information on their arctic nesting habitat.

6) Locating salmon and albacore by their association with thermal fronts.

7) Preventing equipment loss in the crab fishery by better weather and ice forecasts.

8) Providing better environmental forecasts for the Interamerican Tropical Tuna Commission.

I have appended a few documents that I acquired at NASA headquarters pertaining to the experimental plans and cost-benefit studies.

August 9 - U.S. Geological Survey, Reston, Virginia: Dr. Paul Teleki, Environmental Team Leader, Synthetic Aperture Radar System.

The Synthetic Aperture Radar (SAR) to be flown on Seasat is perhaps the most complex instrument planned for this satellite. Dr. Teleki is responsible for coordinating this experiment. He is rather skeptical of many of the "applications" experiments associated with other satellite programs. He views Seasat-A as a research vehicle and hopes the results obtained from this satellite will yield significant "scientific" results. He is also somewhat pessimistic regarding the funding of Seasat, arguing that too many governmental agencies are involved. Consequently, no single entity achieves a holistic view of the program.

August 10 - General Electric Company, Beltsville, Maryland: Howard Heydt.

I visited G.E. to see the capabilities of the Image 100 system which they demonstrated.

August 11 - NOAA National Environmental Satellite Service, Washington, D.C.: Frank Kniskern, Russ Koffler, Dr. Richard Legeckis, and Dr. John Sherman III.

Kniskern's primary interest is in the analysis of arctic ice. We also talked about the costs and delivery times associated with obtaining data from NESS. (I did not take good notes on this, however, I believe the cost is about $3.00 per scene and $50 for data tapes.)

Dr. Legeckis and I talked about the education of a "remote sensor." His attitude is traditional -- teach basics so that as applications develop, users will be prepared to accept the technology.

Dr. Sherman has supported considerable work in optical oceanography related to remote sensing applications. I believe he would be receptive to a proposal from us if we could develop a good experiment off the northern California coast.

August 12 - NASA Goddard Space Flight Center, Beltsville, Maryland: Dr. Philip Cressy, Jr., Buzz Sellman, Dr. Nick Short, Dr. Jim Mueller.

I met with two groups at Goddard -- one assigned with the development of an Applications Assistance program and the other devoted to research activities.

The applications assistance program is directed by Dr. Philip J. Cressy, Jr. This group is responsible for implementing the NASA "technology transfer" directive. This program is still in the formative stages. They claimed their ability to expedite the development of their program has been hampered by excessive administrative review and approval procedures.

The technology transfer program at GSFC has three elements: a marketing group to investigate potential users, a training and user assistance group, and a hardware (and software) group.

The training and user assistance program is headed by Sellman. However, this program is also influenced by Nick Short who presently acts as a staff advisor to Cressy.

Short has prepared a valuable document outlining some of the desired elements in a training program. I agree with a number of his ideas regarding the means of implementing educational programs and believe this document could serve as a framework for designing our own programs (at AMES). Short may be available on 10-11 November to discuss educational policies. I feel we should take advantage of this opportunity to meet with him at AMES.

One of the principal decisions to be made in developing a user-assistance program concerns the output mode of the data. In this regard, Sellman made a valuable criticism of the Slidell facility. He feels a trainee at Slidell leaves with a need for a $100K image-processing facility and a rather poor understanding of the basic functions "behind the push buttons." He feels a better approach would be to train potential users on a remote terminal, to emphasize statistical basics, and to teach the interpretation of alpha-numeric outputs. The training of a person in this type of program would cost only a few hundred dollars.

Cressy's past training programs have been handled in two ways. He has sponsored courses at Penn State (Cressy promised to get me a course syllabus for an up-coming course) and he works with potential users on a one-on-one basis. His philosophy was stated emphatically -- "to cut the cord" and end the user's dependence on support from his laboratory once the trainee reaches a certain level of confidence.

On an important but separate topic, Cressy said to keep an eye on a relatively new computer company, Commodore, which has entered the mini-computer field. Evidently they have, or will have, a system equal in capacity to the HP system now used for image processing -- at a fraction of the cost.

Cressy's group is also evaluating several hardware components associated with digital image processing, such as line printers and keyboard consoles. Their experience may prove useful to NASA Ames when we begin ordering equipment.

I also met with Jim Mueller who works under Vince Salomonson in the R & D group at GSFC. Mueller is an oceanographer interested in the color analysis of ocean water, an extension of his Ph.D. work at Oregon State University. He is also using remotely sensed data in the analysis of sea ice and oceanic heat capacity.

Mueller's thesis on ocean-water color is quite appropriate at this time because he examined the statistical independence of wave-length bands used to describe ocean-water color. This kind of information is pertinent to deciding how many and which spectral bands are necessary to describe ocean-water color. From recent measurements, he feels his Oregon results are applicable over a larger geographical area.

Mueller is continuing his work in this field and will be at Ames during the second week of September for U-2 flights over Monterey Bay. He has contracted with Oregon State University and the Navy Postgraduate School for support activities.

Ocean-color analysis, even though it is an extension of Mueller's thesis, is not the major activity in Mueller's group. Most of their present activity concerns the relationship between the ocean's heat capacity and climate. This work is in anticipation of future satellite measurements. Another activity being pursued by this group is the analysis of Antarctic sea ice.

August 15 - Smithsonian Institution, Washington, D.C.

I spent the day at the National Air and Space Museum.

August 22-23 - Technology Applications Center, University of New Mexico, Albuquerque, New Mexico: Dr. Stan Morain, Director.

Dr. Morain is presently involved in a project, under contract to Moonyhan at Slidell, quite similar to the one I've been looking at this summer -- to assess what user needs are, especially in the academic community, and to advise Slidell of what training programs are necessary to meet those needs.

Morain felt very strongly about the location of technology transfer centers. He believes applications centers should reside in the university system, instead of being located at NASA research centers. From his perspective, then, he believes the NASA monies for technology transfer should be used to activate an existing academic institution (like Humboldt State University) rather than to develop a separate facility near AMES.

Morain has assembled educational materials for a number of courses for a variety of users, but unfortunately, the information is proprietary to the companies that pay for the courses.

August 29 - Scripps Institution of Oceanography, La Jolla, California: Dr. R. L. "Buzz" Bernstein, Mr. Gerry McNally.

I met with Bernstein and McNally to discuss an experiment near Cape Mendocino planned for this September. The experiment is designed to examine the hypothesis that the barotropic component of the oceanic velocity field is diverted seaward by the Mendocino Escarpment. Evidence that cold upwelled water is diverted offshore is available from satellite thermal images, and Bernstein believes this surface water is coupled to the barotropic component below.

HSU can help in this experiment by launching two parachute drogue buoys during our student cruises this September. The buoys will be tracked by satellite. If all goes well, Bernstein suggested a data meeting in a few months to discuss the results.

I also talked with Terry Hendricks who has been involved in coastal currents studies (he was the California Water Quality Control Board's representative on a coastal current project in which I was involved last year). He has looked at NOAA 5 data in the Southern California Bight and has done some analysis with this data. His data suffers from the same malady that will most likely affect us -- overcast conditions for months at a time.

August 31-September 1 - Jet Propulsion Laboratory, Pasadena, California: Len Bryan.

Len Bryan and I spoke about the SAR system on Seasat and a few of its interesting applications -- the measurement of ocean wave lengths, the identification of fishing boats within the 200-mile limit, and the analysis of sea ice, his main interest.

The most enlightening part of our conversation related to the state of many Seasat experiments. Since there had been some controversy over whether microwave systems would be able to measure sea surface features, several instruments were flown on an experimental basis. Data on several phenomena now exist, but the relation between their cause and effect has yet to be understood. Thus the emphasis of the current Seasat-A experiments is on research -- to understand the microwave interaction at the sea's surface. Applications programs, such as those associated with the Landsat satellites, are still in their infancy.

September 2 - Department of Geography, U.C. Santa Barbara: Dr. Jack Estes, Fred Ennerson, Earl Hajic.

UCSB has an established remote sensing program and my interest there was to learn about their program and compare it to others. They offer a three quarter sequence: Photo Interpretation, Remote Sensing, and Nonconventional Imaging Systems (I.R. and microwave). In the Remote Sensing course, students are encouraged to take a concurrent course in elementary statistics. I was interested in this because of the statistical concepts involved in the analysis of multispectral images. More complex matters of multivariate statistics are taught in an in-house "quantitative methods in geography" course. By talking to two of Estes's grad students, I felt they had a basic knowledge of maximum likelihood ratios, decision functions, and Fourier transforms -- even though I doubt they would be able to calculate any of these functions. Their point of view was that the geographer and electrical engineer looked at two sides of the remotely sensed image. What the geographer lacked in quantitative ability, the engineer lacked in "viewing the landscape".

Their courses are supplemented with laboratory sessions at a computer terminal. Hajic promised to send me a hand-out set for the lab sessions and will send some of the students' term papers if I request them (I was interested in one on marine aspects and another on land use which included some color photos illustrating ground truth).

Their software (LARSYS and DIRS) is being changed from BASIC to UNIX. Their facilities include a PDP 11/45 and an I^2S VP-8 image analyzer.

I received a syllabus for each course they offer and Ennerson demonstrated the library routines on UNIX. (Incidentally, he may be a good consultant to set up a system!)

September 6-9 - NASA, Ames-Research Center, Mountain View, California.

The visit to Ames culminated my two-month visit to various NASA facilities, educational institutions, and research institutions. I participated in a variety of administrative and technical meetings related to Western Regional Applications Program.

PART III: Proposed Outline for a Remote Sensing Short Course Intended for the Western Regional Applications Assistance Program.

Objectives:

1) The principal objective is to learn how Landsat-type data can be interpreted to reveal meaningful information about our resources.

2) An additional objective is to acquaint the student with several types of computer hardware systems that are capable of processing Landsat-type data.

Methods:

1) The core of the program will be developed through the traditional lecture/problem set technique. The subject material will fall into the disciplines of physics and statistics.

2) Evening reading assignments will precede the next day's activities. The first reading assignment should be completed before the course begins.

3) Some "core" material will be presented via 35mm slide-tape units.

4) Elective slide-tape units will be available.

5) Laboratory "work sessions" will be centered on a case study of the analysis of a Landsat scene, and a demonstration and "hands-on" experiences related to computer hardware selection alternatives.

6) Individual conferences with applications experts.

DAY 1

0830 **Course description: goals and methods**

a) **Information content in electromagnetic signatures of the earth's surface.**
b) **Obtaining data from the government.**
c) **Computer systems hardware alternatives.**

0930 **Have students submit information relating to individual interests in course.**

COFFEE

1000 Introductory lecture: Remote sensing technology.
*LARS IN 110474
Question/Answer period.

1100 Minicourse: The physical basis of remote sensing (LARS MC).

1200 LUNCH

1300 Minicourse: Multispectral scanners (LARS MC).

1400 Discussion of Landsat with an emphasis on the data-handling system. The objective is to show relationship between the geographical pixel and the corresponding location on the data tape as it is archived at EROS.
Problem: calculate the number of bits in a Landsat scene.

1430 Introduction to computer hardware systems. Emphasis is on what kinds of hardware (specs) are necessary to get data off tapes and into memory. Do not present "data analysis" software yet. Concentrate on the amount of information and accessing ease vs. cost.

1530 Lab I - Hands-on experience of getting information into memory.

1630 How to order Landsat-data.

Homework: Fill out Eros forms

Reading for next day: LARS IN 031573

1930-2100 COCKTAIL PARTY

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*Material to have been read before classroom presentation. LARS IN means LARS information note. LARS MC means LARS minicourse.

DAY 2

0800 Check EROS forms.

0830 Elementary software packages: regridding, geometrical corrections.

COFFEE

0930 Lecture: Machine processing of remotely sensed data.
*LARS IN 031573

1030 Lecture: Spectral reflectance characteristics of vegetation.

1130 Problem set -- to be completed before lunch.

LUNCH (correct problem sets)

1300 Review of problem set.

1330 Lecture: Introduction to quantitative remote sensing (pattern recognition and temporal variations) -- after Landgrebe's notes and video tape.

1430 Minicourse: Spectral reflectance of characteristics of earth surface features (LARS MC).

1530 Lecture: On the multivariate approach -- after Landgrebe's notes and video tape.

1600 Review of statistics -- covariance, covariance matrix, correlation.
Problem set on the above.

1900 Evening seminar on some application of remote sensing -- perhaps the noxious weed (?Ragwort) study by Ethel Bauer.

DAY 3

0800 Review of problem set.

0830 Minicourse: Interpretation of multispectral scanner images -- LARS MC.

COFFEE

1000 Lecture: System parameters fundamental to information extraction -- after Landgrebe's notes and video tape.

1100 Minicourse: Pattern recognition in remote sensing (LARS MC).

LUNCH

1300 Discussion of previous minicourse.

1330 Minicourse: Typical steps in numerical analysis (LARS MC).

COFFEE

1500 LAB II - Application of the minicourses on pattern recognition and numerical analysis.

1600 Lab III - Application of some "analysis" software.

Problem set:

Reading assignment: LARS IN 111572

1900 Evening seminar - PNW Project.

DAY 4

0800 Review of problem set.

0830 Lecture: Pattern recognition for remote sensing applications -- after Swain's notes and video tape -- LARS IN 111572.

COFFEE

1000 Lab IV - Review of hardware options on "how to build your own processing center".

1100 Lecture; Cluster analysis and sample classification. *LARS IN 111572

LUNCH

1300 Lab V - Cluster analysis

COFFEE

1500 Minicourse: Elective

1600 Minicourse: Elective

DAY 5

0800 Review of problem sets.

0830 Lecture: A look at other (Non-Landsat) types of remotely sensed data.

0900 Minicourse options: Radar, thermal IR, and various applications.

COFFEE

1000 Introduction to browse files.

1100 Lab VI - Input-output devices.

LUNCH

1300 Individual discussions with applications experts.

HUMBOLDT STATE UNIVERSITY Arcata, California 95521 (707) 826 3931

Department of Geology

October 13, 1977

Mrs. Donna Hankins, Director
Northern California Remote Sensing
and Technology Transfer Project
Center for Community Development
Humboldt State University
Arcata, CA 95521

Dear Donna:

In our conversation over lunch last Wednesday, we discussed procedures for grant applications in the remote sensing field. The conversation and your enthusiasm encouraged me to present an idea that I have been mulling over since I did field work for Exxon in southwestern Colorado in 1971 and 1972. I have not followed up on the idea previously because I am somewhat ignorant of what types of imagery are available and I am virtually untrained in remote sensing technology. The possibility of receiving the training I will need and of obtaining the proper imagery for this project prompts me to write to you now. I believe the project has merit and I am convinced that at least one of the members of the HSU Geology faculty should be well-versed in modern remote sensing applications.

I have outlined briefly on the attached pages the research I would like to carry out, as well as the benefits that should accrue to me and to the University if the project receives support. I will appreciate any comments or suggestions you and your associates may have regarding the proposal, and any help you can give me in locating the proper agency to review the proposal. I will be grateful for any assistance you can give me.

Sincerely,

John D. Longshore
Professor
Department of Geology

JDL:bw

Attachments

IDENTIFICATION OF CALDERAS, VOLCANO-TECTONIC STRUCTURES,
AND HYDROTHERMAL ALTERATION ZONES USING
REMOTE SENSING IMAGERY

Background and Objectives:

The San Juan volcanic field of southwestern Colorado consists of intermediate to silicic volcanic flows and plugs of Tertiary age covering an area of over 20,000 square kilometers. An unknown number of vents erupted voluminous ash flows, subsequently collapsing to produce calderas or elongate depressions from five to forty kilometers in length. Uplift, glaciation and stream erosion have partially obscured many of these major volcanic structures, though in some cases stream valleys developed around resurgent caldera margins, accentuating the shape and form of the structures. Soon after mining activity began in the area in the late 19th century, geologists recognized that many of the caldera collapse structures served to control hydrothermal and ore-bearing solutions. Several of the calderas (Silverton, Creede, Lake City) became important gold, silver and base metal mining centers.

The first major geological study of the San Juan region was written by Larsen and Cross in 1956. Since that time detailed maps of several smaller areas within the region have been published (for instance: Lipman, 1976; Luedke, 1962, Steven and Lipman, 1976; and others), and extensive research has been done on the area's mining districts to determine ore controls and types (for instance: Varnes, 1963; Steven and Ratte, 1965, and others). Mapping by U. S. Geological Survey scientists helped to locate several caldera collapse structures and volcano-tectonic features that are topographically obscure (Lipman, 1975, Lipman, et. al., 1973, Steven, 1975).

The objective of this proposed research is to determine if remote sensing imagery can delineate details and minor structural features of the known caldera and volcano-related structures within the San Juan field, and to locate collapse structures and vents associated with ash flows whose source areas have not yet been identified by surface mapping. An additional objective will be to identify hydrothermally altered zones within the volcanic field by imagery analysis, as these zones are obvious targets for mineral exploration. Results of this study should be of immediate interest to governmental agencies and mining companies concerned with mineral resources of the area.

Proposed Plan of Research.

I believe the objectives of this research can be achieved within two years; the work should be divided into two phases:

1. Training and preliminary imagery analysis
   I have taught geology for the past twelve years; I have spent several field seasons in mineral exploration for industry and I am familiar with most classical mapping techniques and geological interpretation

methods. I have also written general geological descriptions of regions in the United States for instructional use, utilizing Landsat and Skylab imagery. However, I have had no formal training in remote sensing, modern imagery interpretation, nor even in the types of imagery that are available today. I will not be able to do this research properly without additional training, and my hope is that I will be able to obtain the necessary instruction at one of the N.A.S.A. regional centers, perhaps by working directly with the personnel there. If this can be accomplished in the summer of 1978 (6-8 weeks ?), I should be able to complete preliminary analyses of available imagery (Landsat, U-2, Skylab, low-level aircraft) during the 1978-79 academic year.

2. Field checking and final imagery analysis
I do not believe that preliminary results of imagery analysis will be supportable without ground checks to determine accuracy of the interpretations. Field inspection of possible lineaments, rock types, collapse features, and alteration zones identified with imagery would verify the accuracy and reliability of the interpretations. Field work in the San Juans should occupy from six to eight weeks of the summer of 1979. Final imagery analysis and drafting a report could be accomplished during the 1979-80 academic year.

Expected Results and Benefits of the Research:

Results of the project should be of direct benefit to mining firms involved in mineral exploration in the San Juans. Faults, collapse features, and alteration zones which might be undetected by ground surveys or which might take months to map by field teams, may be detectable and mappable using remote sensing. The results could accelerate exploration in the area. I spent three field seasons in the western San Juans and I know that mapping in the area is extremely difficult due to the rugged terrain. Maps and interpretations derived from the project should also assist the U. S. Forest Service, which is responsible for managing the majority of the area. If successful, the research should serve to stimulate use of remote sensing data in locating volcanic structures and mineralized zones in other areas of the western United States, particularly Nevada, Idaho, Oregon and Washington.

Additionally, though perhaps less easily measured, the benefits of the project would accrue to the Geology program and students of Humboldt State University. The Geology faculty does not have a staff member trained in modern remote sensing. We offer a course in aerial photograph interpretation which could and should be expanded to encompass other remote techniques in order to prepare students for jobs of the future.

In this context, the training and experience I would receive from this project would be highly beneficial to future generations of students at Humboldt. As with all other research done by the Geology faculty at the University, I plan to involve students in this project to assist with both imagery interpretation and with the field work.

References Cited:

Larsen, E. S., Jr., and Cross, W., 1956, Geology and petrology of the San Juan region, southwest Colorado: U. S. Geol. Survey Prof. Paper 258, 247 pp.

Lipman, P. W., 1976, Geologic map of the Lake City caldera area, western San Juan Mountains, Colorado: U. S. Geol. Survey Misc. Inv. Map.

Lipman, P. W., 1975, Evolution of the Platoro caldera complex and related volcanic rocks, southeastern San Juan Mountains, Colorado: U. S. Geol. Survey Prof. Paper 852, 128 pp.

Lipman, P. W., Steven, T. A., Luedke, R. G., and Burbank, W. S., 1973, Revised volcanic history of the San Juan, Uncompahgre, Silverton, and Lake City calderas in the western San Juan Mountains, Colorado: U. S. Geol. Survey Jour. Research, v. 1, no. 6, p. 627-642.

Luedke, R. G., 1962, Geology of the Ouray Quadrangle, Colorado: U. S. Geol. Survey Quad. Map GQ-152.

Steven, T. A., 1975, Middle Tertiary volcanic field in the southern Rocky Mountains: Geol. Soc Amer. Memoir 144, p. 75-94.

Steven, T A., and Lipman, P. W., 1976, Calderas of the San Juan volcanic field, southwestern Colorado: U. S. Geol. Survey Prof. Paper 958, 35 pp.

Steven, T. A., and Ratte, J C., 1965, Geology and structural control of ore deposition in the Creede District, San Juan Mountains, Colorado: U. S. Geol. Survey Prof. Paper 487, 90 pp.

Varnes, D J., 1963, Geology and ore deposits of the south Silverton mining area, San Juan County, Colorado: U. S. Geol. Survey Prof. Paper 378-A, 56 pp.

APPENDIX III

Documentation. Community Workshops, Presentations and Lectures as Part of Grant Activities

* Lists of training workshops and community presentations

* "A Forum for the Exchange of Information on Available Resource Management Data and Data Most Needed by People and Agencies in Northern California", Report on Workshop in Weaverville, July 12-13, 1978 by Kamila Plesmid

TRAINING	DATE	WHERE	NUMBER ATTENDING	PRESENTOR(s)	LEVEL OR TYPE OF PRESENTATION	NOTES
Hoopa/Yurok Indians	6/29/77	Weitchpec	8	L. Fox, J. Webster, K. Plesmid, L. Archambeau	Introduction/ Planning	Introduction to Grant program, begins coordination for project plan.
Hoopa/Yurok Indians	7/18/77	HSU, Arcata, CA	8	L. Fox, J. Webster, K. Plesmid, D. Hankins, L. Archambeau	Coordination/ Training	Input to General Plan development.
Humboldt County Board of Supervisors	9/26/77	Eureka, CA	30	D. Hankins, L. Fox, J. Webster, K. Plesmid, L. Archambeau	Information/ Instructional	Workshop to inform Board of Supervisors and to present basics of Remote Sensing.
Ida Hoos Workshop	9/27/77	Eureka, CA	30	D. Hankins, L. Fox, J. Webster, K. Plesmid, L. Archambeau	Instructional program of Social Aspects of Remote Sensing Technology	Led to development of action plan for HSU professorial involvement.
Agency/Staff Workshop (7 Federal, State and Local Reps.)	10/15/77	Arcata, CA	27	L. Fox	Instructional/ basics of Remote Sensing Technology. Applications - Overall Training.	Provided both agency personnel and staff with full range of technological developments.
Humboldt County Department Heads and Staff	11/14/77	Eureka, CA	26	D. Hankins, L. Fox, J. Webster	Instructional/ Coordination	Develop coordinated program for Humboldt County involvement with project.
Faculty Workshop HSU	12-3-77 & 1-7-78	HSU, Arcata, CA	52	D. Hankins, L. Fox, J. Webster, R. Hodgson	Training/Planning	Instruction on basics of Remote Sensing and planning of faculty interaction with grant.
Mendocino Community Organization	1-22-78	Mendo-cino, CA	17	D. Hankins, J. Webster, K. Plesmid, L. Fox	Instruction/ Simulation activity	Inform on basics of Remote Sensing - use of simulation activity to "teach" Remote Sensing.
Remote Sensing of the Environment	1-11-78 to 3-15-78	HSU Arcata, CA	126	L. Fox,	Introduction/ Training	Ten week course offering to HSU students and community attendees on full theory and application of Remote Sensing. Course being continued as HSU department offering.

TRAINING	DATE	WHERE	NUMBER ATTENDING	PRESENTOR(s)	LEVEL OR TYPE OF PRESENTATION	NOTES
Department of Water Resources	2-3-78	HSU, Arcata, CA	7	D. Hankins, L. Fox	Planning/ Instructional	Initial contacts/information for possible program with Trinity River Task Force.
Department of Water Resources	2-27-78	Red Bluff, CA	25	D. Hankins, S. Norman, P. Williams	Instruction	Instruction on basics of Remote Sensing and project planning.
Landsat C Conference	3-3-78 to 3-5-78	Santa Maria, CA	350	L. Fox, D. Hankins	Informational	Fox worked with industry representatives on reflectance and tools for Landsat data. Hankins coordination, organizer of conference program.
Remote Sensing of the Environment	3-15-78	HSU, Arcata, CA	120	D. Hankins	Instructional	Social implications of Remote Sensing technology.

COMMUNITY PRESENTATIONS	DATE	WHERE	NUMBER ATTENDING	PRESENTOR(s)	LEVEL OR TYPE OF PRESENTATION	NOTES
Citizens Task Force	6-6-77	HSU, Arcata, CA	15	D. Hankins, L. Fox, J. Webster, K. Plesmid	Informational/ Coordination	Inform task force of grant award and anticipated activities.
Arcata Redwood Corporation	7-25-77	Arcata, CA	4	L. Fox, K. Plesmid	Informational	Explained program--gained industrial participation with task force.
Louisiana Pacific Lumber Company	7-27-77	Eureka, CA	4	L. Fox, K. Plesmid	Informational	Explained program--gained industry representation to task force.
Pacific Lumber Company	8-1-77	Scotia, CA	3	L. Fox, K. Plesmid	Informational/ Basic	Very interested in developing an industrial project--representation gained for task force.
Humboldt Bay Municipal Water District	8-11-77	Eureka, CA	15	D. Hankins	Instructional/ Informational	Activities of grant and program developments.
Arcata Rotary Club	8-24-77	Arcata, CA	50	D. Hankins, K. Plesmid	Informational	Develop contacts and support with local business groups.
County Library In-Service Workshop	9-21-77	Eureka, CA	50	K. Plesmid	Instructional/ Information	Instruction in how Remote Sensing could be used in Elementary schools.
Citizens Task Force	9-22-77	HSU, Arcata, CA	22	D. Hankins, L. Fox, J. Webster, K. Plesmid	Informational/ Coordination	Periodic review of grant activities - request for support of future activities.
Ferndale Lions Club	10-26-77	Scotia, CA	20	K. Plesmid, J. Webster	Information	General presentation of grant and Remote Sensing applications.
Natural Resources Honor Society	10-27-77	HSU, Arcata, CA	15	D. Hankins	Information	Solicit support and/or research programs from students.
Eureka Southwest Rotary Club	10-28-77	Eureka, CA	40	K. Plesmid	Information	General presentation of grant and Remote Sensing applications.
Walden, Colorado	11-1-77	Walden, Colorado	30	D. Hankins	Information	Presentation on Remote Sensing and grant to State of Colorado representatives. Observe COMARC, Inc. Community input to decision making - Delphi session.

COMMUNITY PRESENTATIONS	DATE	WHERE	NUMBER ATTENDING	PRESENTOR(s)	LEVEL OR TYPE OF PRESENTATION	NOTES
American Society of Civil Engineers	11-17-77	Eureka, CA	50	D. Hankins	Informational	Speaker at Symposium.
Humboldt County Business Women's Club	11-15-77	Eureka, CA	35	D. Hankins	Informational	Activities/accomplishment of grant program.
Eureka Lions Club	12-8-77	Eureka, CA	45	K. Plesmid	Informational	General presentation of grant and Remote Sensing applications.
McKinleyville Lions Club	1-24-78	McKinley-ville, CA	25	K. Plesmid	Informational	General presentation of grant and Remote Sensing applications.
Northcoast Counties Supervisors Associations	2-2-78	Santa Rosa, CA	20	D. Hankins, L. Fox, S. Norman, P. Williams	Informational/ Instructional	Presentation of grant and NASA wrap program in Northern California.
Career Development Workshop	2-7-78	HSU, Arcata, CA	30	J. Webster, L. Fox, K. Plesmid	Informational/ Instructional	Presented career potentials in Remote Sensing - basics of Remote Sensing.
California Remote Sensing Advisory Committee	2-9-78	Sacramento CA	15	D. Hankins	Organizational Meeting	
HSU Engineering Club	2-17-78	HSU, Arcata, CA	30	K. Plesmid	Informational	Overview of Remote Sensing and potentials for careers.
Tele Conference	3-23-78	NASA Ames	4	P. Williams, K. Plesmid	Telecommunications conference with Dr. Roberson and Calio on grant activities.	
Trinity River Task Force (11 federal, state and local agencies)	3-28-78	Weaver-viller, CA	20	D. Hankins, S. Norman, P. Williams, J. Webster, K. Mayer	Informational/ Instruction	Presentation led to support for California ASVT
Space and Air Symposium	4-11-78 to 4-12-78	Eureka, CA	50		Informational	In conjunction with Northern California High Schools presented grant program and Remote Sensing applications. In cooperation with California Museum of Science and Industry.

COMMUNITY PRESENTATIONS	DATE	WHERE	NUMBER ATTENDING	PRESENTOR(s)	LEVEL OR TYPE OF PRESENTATION	NOTES
California Remote Sensing Advisory Committee	4-13-78	Berkeley, CA	30	J. Webster	Organizational/ Presentation	Solidify organizational structure, plan future interaction.
Indian Telecommunications Project	4-12-78	2 sites: Montana & New Mexico	200	K. Plesmid/Project	Informational/ Instructional	Developed video-tape presentation on project activities. Transfer of technology to local Indian groups.
Siskiyou Conference	4-14-78 to 4-15-78	Weed, CA	120	D. Hankins	Informational	Presentation of program objectives/activities to conference--participation on regional panel.
American Institute of Planners Conference	4-22-78	Monterey, CA	75	D. Hankins	Informational	Presented panel discussion and address on Remote Sensing.
Environmental Education	5-10-78	HSU, Arcata, CA	10	K. Plesmid	Informational	Class is elementary age - use of aerial photos for map-making--tour of HSU Library display.

STATE	LOCATION--GROUP	SUBJECT	NO. OF PARTICIPANTS	SCHEDULED	COMPLETED	LECTURER
CA	HSU, Arcata	Faculty Workshop	26	12/3/77	12/3/77	Fox
CA	Ames Rsch Ctr	Computer Workshop	7	11/30-12/2/77	12/2/77	
CA	HSU, Arcata	Faculty Workshop	26	1/7/78	1/7/78	Fox
CA	Mendocino--Community Group	Testing of simulation game	75	1/22/78	1/22/78	Project Staff
CA	McKinleyville--Lions Club	Remote Sensing presentation	25	1/24/78	1/24/78	Plesmid
CA	Santa Rosa	WRAP-HSU presentation to Northern California County Supervisors Association (NCCSA)	20	2/2/78	2/2/78	Hankins, Fox, Webster, Norman, Williams
CA	HSU, Arcata	Career Development Workshop Day	30	2/7/78	2/7/78	Fox, Webster, Plesmid
CA	Sacramento	CRSAC Charter meeting	15	2/9/78	2/9/78	Hankins
CA	Santa Maria	Planning meeting for Landsat C Conference	6	2/11/78	2/11/78	Hankins
CA	HSU, Arcata	Presentation to Engineering Club	30	2/17/78	2/17/78	Plesmid
CA	Red Bluff	DWR, Trinity River Workshop	25	2/27/78	2/27/78	Webster, Hankins, Williams, Butler, Norman

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STATE	LOCATION--GROUP	SUBJECT	NO. OF PARTICIPANTS	SCHEDULED	COMPLETED	LECTURER
CA	Santa Maria	Landsat C Conference & Launch	360	3/2-5/78	3/5/78	Project Staff
CA	HSU, Arcata	10-week Introductory Course in Remote Sensing Technology and its Applications	126	1/11-3/15/78	3/15/78	Fox
CA	Hoopa/Weaverville	Meet with DWR/Trinity River Task Force	20	3/27-28/78		Hankins, Webster, Mayer
CA	Eureka High School	California Museum of Science & Industry Symposium	50	4/12/78		Hankins, Plesmid
CA	Weed	Siskiyou Conference	120	4/14-15/78		Hankins
CA	Monterey	AIP Conference	250	4/21-22/78		Hankins, Fox
CA	HSU, Arcata	6-County Remote Sensing of the Environment Institute--to be given for teachers and community persons to provide awareness of technology need integration into curriculum areas; jointly work out teaching strategies and design materials	250	8/27-9/7/78		

THE CENTER FOR COMMUNITY DEVELOPMENT
HUMBOLDT STATE UNIVERSITY
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ARCATA, CALIFORNIA 95521 -- TEL (707) 826 3731 (2,3)
REMOTE SENSING AND TECHNOLOGY TRANSFER PROJECT

TOM PARSONS
Director

American Indian Communities TV Project

American Indian Languages and Literature Program

Community Education Project

Humboldt Co Recreation Project

Indian Mainstream Industries Project

Kotim Een Karuk Ceremonial Society

Multi-Cultural Education Project

N A S A Remote Sensing Technology Transfer Project

National American Indian Repertory Theatre Project

Northern California Health Systems Agency Support Project

Redwoods Community Development Council Project

Wood for Seniors Project

"A FORUM FOR THE EXCHANGE OF INFORMATION ON AVAILABLE RESOURCE MANAGEMENT DATA AND DATA MOST NEEDED BY PEOPLE AND AGENCIES IN NORTHERN CALIFORNIA"

A Cooperative Workshop

July 12-13, 1978
Weaverville, California

Prepared by·

Kamila Plesmid
July 28, 1978

IN COOPERATION WITH CALIFORNIA'S NORTHWEST COUNTIES

INTRODUCTION

One of the major goals of the Remote Sensing and Technology Transfer Project at Humboldt State University is to facilitate the transfer of remote sensing technology to northern California users. In keeping with this goal, a workshop entitled, "A Forum for the Exchange of Information on Available Resource Management Data and Data Most Needed by People and Agencies in Northern California," was held July 12 and 13, 1978, at the Civil Defense Building, Weaverville, California.

Principal workshop cooperators and presentors included the U.S. Geological Survey Geography Program, Reston, Virginia and Menlo Park, California, the California Environmental Data Center, Sacramento, California; the Western Regional Applications Program, NASA Ames Research Center, Moffett Field, California; and the Remote Sensing Project staff, Humboldt State University.

Over two hundred people were invited to attend--representatives of county, state and federal agencies, county and tribal governments, and private industry in the eight counties of northern Califonria. Members of State Assembly and State Senate committees concerned with state resource management were also invited as were representatives from northern California universities interested in the current and future users of remote sensing tools. Of those invited, 43 people participated in the workshop (see Appendix A for list).

As the invitation stated, the workshop was to be a "forum for the exchange of information." Formal presentations were kept to a minimum with the majority of the time spent in a "hands-on" session and in group discussion.

WORKSHOP OBJECTIVES

The main objectives of the workshop were as follows:

1) To provide information on the availability and access to maps or photographic products that assist resource management in northern California;

2) To familiarize participants with the U.S. Geological Survey's Land Use/Land Cover mapping effort currently underway in northern California, an effort that is expected to be completed by January 1979; and

3) To discuss and formalize recommendations on the map, photographic, or special product needs of the state, county and federal agencies in northern California.

PRESENTATIONS

Morning, July 12, 1978.

Day One began with an introduction and welcome by Donna Hankins, Director of the Humboldt State University Remote Sensing Project. This was followed by brief presentations from Dr. James Anderson, Chief Geographer of the U.S. Geological Survey's Geography program; Eugene Napier, Western Region Representative of the U.S. Geological Survey's Geography program; and Mrs. Sally Bay Cornwell, Director of the California Environmental Data Center.

U.S. Geological Survey

Dr. James Anderson has been developing the current land use and land cover classification system used by the U.S. Geological Survey since 1972. Although this standard system can be used with data from conventional sources, it was primarily devised to classify data from remote sensors on either high-altitude aircraft or satellites.

Since 1976, when the definitions of the classification system were revised, the U.S. Geological Survey's Geography program has been compiling maps at 1:250,000 of the coastal areas of the United States. Northwestern California is their current work area, and they expect this series of maps to be completed by January 1979. Eventually, the plan is to map the entire United States, developing an information system as they go. The land use/land cover maps have been digitized and that information has been placed into a digital base with digital tapes available. The U.S. Geological Survey is beginning to develop base maps at 1:100,000 so that, as more of these maps become available, the land use and land cover maps will also be prepared at this scale.

Dr. Anderson, who was visiting the U.S. Geological Survey Western Region Geography program at the time of the workshop, accepted the invitation to participate in the Weaverville meeting because of his desire to understand the current needs of northern California map and remote sensing users. The workshop provided him with the opportunity to acquaint this representative group with the work being done by his department and to involve many of the participants in a review of the northwestern California land use/land cover maps when they are completed.

Eugene Napier, representing the Western Region Geography Program at the workshop, explained the use of the digital tapes that are derived from the land use/land cover maps. He also described the process that is currently underway to develop the northwestern California maps. Northeastern California will be next with the eastern border of California last. His program is interested in having local participation in evaluating the accuracy of the maps, especially the non-urban categories.

Environmental Data Center

Mrs. Sally Bay Cornwell was at the workshop to discuss her state program, the California Environmental Data Center. Currently, she is assessing the state agency needs for resource data and trying to develop a system to coordinate all of the existing information within state departments. Cataloging is going on at this time, and Mrs. Cornwell expects to have an index to the data available in the near future.

In the meantime, Mrs. Cornwell is concerned with where people's "gaps" are in acquiring or learning about state resource information. With that knowledge, long-term plans can be made for the Environmental Data Center. She was anxious to receive recommendations from the northern California participants at the Weaverville Workshop so that the Center would meet their needs.

"HANDS-ON" SESSION

Afternoon, July 12, 1978.

The afternoon of Day One began with a "Hands-on" session so that workshop participants would have a chance to see a variety of map, photographic and satellite products being used in resource planning and management. Participants would also have a chance to discuss their problems and concerns informally with the people working on projects in northern California using the before-mentioned products.

Tables and display areas were designated around the meeting hall for the following people:

--Dr. James Anderson and Eugene Napier, U.S. Geological Survey's Geography program. Samples of the U.S. Geological Survey Land Use/Land Cover maps were on display. Information packets from the National Cartographic Information Center (NCIC) at Menlo Park and 15' quad sheets of the Weaverville/Redding area from the U.S. Geological Survey Topographic Division, Menlo Park were distributed.

--Ms. Sue Norman, NASA Ames Research Center, Moffett Field, California, was at the workshop to discuss the Western Regional Applications Program (WRAP), a 14-state program to transfer satellite technology to state agency personnel.

--Mrs. Sally Bay Cornwell, Director, California Environmental Data Center.

--Charles Ferchaud, Department of Water Resources, Red Bluff, California; DWR State Mapping Program. Samples of DWR maps were displayed. He explained the land use mapping update that is underway in the northern California counties.

--Don Tuttle, Natural Resources Branch, Humboldt County Department of Public Works; Humboldt County Data Bank.

--Ken Mayer, U.S. Fish and Wildlife Landsat Demonstration Project, Humboldt State University. Landsat satellite computer output products were on display to illustrate work in progress on the Hoopa Square and the Klamath Extension, Humboldt and Del Norte Counties. The project is developing a vegetation map, using Landsat, to study the fisheries resources of the area.

--Humboldt State University Remote Sensing and Technology Transfer Project, May 8, 1978 U2 photography of northwestern California. The entire flight was available for viewing in the 6" focal lense size. Samples of the 24" lense photography were also available. The Trinity County Planning Department provided a light table for the viewing.

--Jack Naylor, private contractor specializing in low-altitude aerial photography. Samples of his work in black-and-white transparencies were displayed.

SMALL GROUP DISCUSSIONS

The remainder of the afternoon was set aside for small group discussions. Participants were asked to sit in on one of three group sessions Federal agencies, state agencies, or county personnel. (Participants from private industry and universities were invited to join the group of their choice.)

Questionnaires were distributed to all the participants to aid the small group discussion (see Appendix B). Each group was to define the following:

1) Maps and photography used by each agency represented.

2) Additional maps and photography needed, including customized or special products.

3) A list of product priorities for each agency.

4) A list of priorities for each of the three groups.

Each discussion group was also to designate a spokesperson to report on the group in Day Two morning session.

Discussion leaders for each group were:

Federal: Dr. Larry Fox, Humboldt State University Remote Sensing Project
State: Mrs. Sally Bay Cornwell, California Environmental Data Center
County: Don Tuttle, Humboldt County Public Works, Natural Resources Department

TABLE 1.
WORKSHOP QUESTIONNAIRE

33 questionnaires were completed. Ten were from Federal agency representatives, ten were from California State agencies; five questionnaires came from county representatives; four from private industry; and three from Humboldt State University personnel. (See Appendix B for complete questionnaire.)

#1 & #2. What map and photography scales do you use?

Scale	Map	Photo-graphy	Total
1:6,000 or larger	11	16	27
1:12,000	8	4	12
1:15,840	--	7	7
1:24,000	20	7	27
1:32,500	--	5	5
1:62,500	12	4	16
1:80,000	--	3	3
1:100,000	3	--	3
1:120,000	2	3	5
1·130,000	1	5	6
1:250,000	3	--	3
1:500,000 or smaller	3	--	3

#3. How do you use these maps and photos?

Base Maps	5
Planning	14
Inventory	7
Land Use Mapping	8
Land Cover Analysis	
A) Habitat	3
B) Agriculture	4
C) Vegetation	4
D) Timber	9
E) General	2
F) Other	5

#4. How often do you update?

Constantly	4
Monthly	2
Yearly	5
2-5 Years	11
5-10 Years	4
Varies	6

#5. What maps do you need?		#6. Are they available? Yes	No	Sometimes
Base	4	1	1	--
Orthophoto quads	4	--	4	--
Land Use	24	4	19	4
Land Cover	21	2	13	2
Other				
A) Geology	5	--	5	--
B) Hydrology	2	--	2	--
C) Soils	3	--	3	--

TABLE I continued.

#3 & #5. What type of photography do you use? do you need? Is it available?					
			AVAILABLE?		
Type	Use	Need	Yes	No	Sometimes
Black & White	10	12	2	3	4
Color	18	23	8	4	6
Color IR	12	14	7	1	5

#7. What are the barriers to obtaining your needs?	
Cost	24
Time	5
Politics	6
Availability	9
Lack of Information	7

#8. Are your needs different from your agency's?	
Yes	No
18	13

#9. Can you use other agency efforts?	
Yes	No
27	5

#10 & #11. What are your sources for maps and photography?			
Source	Maps	Photography	Total
U.S. Geological Survey	22	5	27
EROS Data Ctr./NASA	1	6	7
Forest Service	6	9	15
Other Federal Agencies	5	--	5
Calif. Dept. Water Resources	7	4	11
Calif. Dept. of Forestry	3	--	3
Caltrans	2	1	3
Other Calif. Agencies	4	--	4
County	7	1	8
In-house	4	6	10
Private Contractor	3	12	15

#12. What determines your map and/or photography needs?			
Federal Laws	12	Ongoing Program	14
State Laws	15	Individual Job	5
County Plan	4		

The majority of the attendees divided themselves equally between the state and federal groups. County representatives had the poorest showing at the workshop, in part, due to a tightening of travel funds because of the passage of Proposition 13 Those county people that were in attendance filled out additional questionnaires for other departments within their counties. The northern California counties not represented at the workshop have been contacted to fill out questionnaires.

At the end of the day, the questionnaires were collected so that an initial tabulation could be made for the following morning--one reflecting the common needs of the participants. Day One of the workshop adjourned at 4 PM.

SUMMARY FORUM

Morning, July 13, 1978.

Tables were set up for a "round table" discussion on Day Two of the workshop. Donna Hankins, Humboldt State University Remote Sensing Project Director, began the Summary Forum with a rundown of the common elements in the first five questions of the previous day's questionnaire. The following table is a full break-out of those answers. (See Table 1.)

LARGE GROUP DISCUSSION

The second part of the summary forum focused on the group priority reports. These priorities emerged from the small group discussions on Day One. Federal priorities, as reported by Dr. Larry Fox, Humboldt State Remote Sensing Project, were photographic needs. State agency needs, as reported by James Wardlow, Department of Water Resources, were primarily mapping needs. And the northern California counties, as described by Don Tuttle of the Humboldt County Public Works Department, needed larger scale maps and photography than either the federal or state agencies needed.

<u>Federal Priorities</u>

1) Color photography at 1:48,000.
2) Orthophotoquads, reprintable at a low cost, at 1:24,000.
3) Small scale photography at 1:100,000.

<u>State Agency Priorities</u>

1) Up-dated 1·24,000 quads and 1:100,000 base maps.
2) Current photography, at least every 5 years.
3) Complete vegetation mapping at 1·1,000 and 1:100,000 for county-size maps.
4) Common map scales for state base maps.
5) Access to all California maps.

County Priorities

1) 1:12,000 quality base maps showing roads, streams, townships range, section line, and cultural features.
2) 1:12,000 color photography.
3) Completion by U.S. Geological Survey of 7½' quads for the northern California counties as well as up-dating the existing 15' quads.

DEVELOPING WORKSHOP ACTION ITEMS

After the priorities of the three main groups at the meeting were discussed, the second phase of the Day Two session began. This phase was the generation of action items for meeting the map, photographic or special product needs of northern California agencies and private sector.

Each participant received a summary sheet (see Appendix C) and was given ten minutes to write down five action items (in no particular order) that reflected the needs of the representatives at the workshop. In making these recommendations, they were to consider what agency or group could provide the needed items; the priority items that had already been discussed; common needs in northern California; and cooperative methods that could be used to fill the needs.

The next step in the process was to number the five items as to their priority in each participant's mind and to give reasons for and against each of these items occuring. Such a breakdown would focus attention on the barriers to be overcome if action was to be taken on any of the items.

Because of time constraints, only the first priority of each participant was called for, and the Number One recommendations were listed on a large tablet for the whole group to see. What emerged as a general concensus, were two distinct areas of concern: up-to-date common scale maps and a statewide information system.

FIVE ACTION ITEMS OF THE WORKSHOP

1) The need for standardized map scales throughout California at 1:100,000; 1:24,000; and 1:12,000. Scales to be used on base maps, overlay maps, vegetation or land use/land cover mapping. (Standard coordinates system to be part of standardized maps.)

2) The need for a statewide communication network or information center/repository/clearing house that would provide an interface between current and future resource products and data and the various state agencies, county governments, private industries, and federal agency branches in California.

3) Completion of the 7½' quads of northwestern California by the U.S. Geological Survey, preferably as ortho photo quads.

4) The need for statewide vegetation maps that meet broad needs and can be updated regularly and frequently (with Landsat).

5) The need for the state and counties to be photographed on a regular basis (with coverage by the U2).

FOLLOW-UP ACTIVITIES

As a follow-up to the action items of the workshop, the group directed Donna Hankins, coordinator of the workshop, to write a letter to Mrs. Sally Bay Cornwell, Director of the California Environmental Data Center, on behalf of the workshop informing her of the specific needs of the northern California area. The letter was to request Mrs. Cornwell to 1) meet with the California Mapping Advisory Committee to discuss northern California priorities, 2) take up the question of completion of the 7½' quad sheets with members of the U.S. Geological Survey Topographic Division, Menlo Park, California; and 3) incorporate the needs expressed at the workshop into her long-range plans for the California Environmental Data Center.

At the same time, various members of the workshop, representing federal, state, and county interests volunteered to comprise an informal committee that might pursue the northern California needs with U.S. Geological Survey representatives at a later date. Gene Napier, U.S. Geological Survey Geography Program, said that he would be glad to meet with this informal committee and/or organize a meeting between this group and the Topographic Division.

The workshop adjourned at 12 Noon, July 13, 1978.

APPENDIX A
WEAVERVILLE WORKSHOP
ATTENDANCE LIST

Name	Agency/Address	Phone
Nancy Tosta	CA Div Forestry, 1416 Ninth Street, Soil Erosion Study, Sacramento, CA 95814	916-322-0163
Richard Gissibl	USFS McCloud Ranger Dist., Drawer I, McCloud, CA	916-964-2184
John Glines	USFS Hayfork Ranger Dist., P.O Box 159, Hayfork, CA 96041	916-628-5227
Eugene C. Napier	US Geological Survey, Geography Program, 345 Middlefield Rd. Mail Stop 31, Menlo Park, CA 94025	415-323-8111 ext. 2836
Robert Sathrum	Humboldt State Univ., Library, Arcata, CA 95521	707-826-3416
Dennis Giovannetti	Aero-Marine Research, Geology Div., 1690 Victor, Arcata, CA 95521	707-442-0359
James M. Wardlow	Dept. Water Resources, Planning Div., P.O. Box 388, 1416 Ninth St., Sacramento, CA 95802	916-455-9844
Bill Bowman	Arcata Redwood Co., P.O. Box 218, Arcata, CA 95521	707-443-5031 ext. 24
Charles L. Ferchaud, Jr.	Dept. Water Resources, Land and Water Use, P.O.Box 607, Red Bluff, CA 96080	916-527-6699
Robert R. McGill	Dept Water Resources, Northern Dist., P.O. Box 607, Red Bluff, CA 96080	916-527-6530
Ernest E. Lusk	CA Dept. Health Services, Vector Biology and Control, 2135 Akard Ave., Rm 14, Redding, CA 96001	916-246-6345
B. J. Smith	Dept. Water Resources, Northern District P.O. Box 607, Red Bluff, CA 96080	916-527-6530
Robert A. Rasmussen	Private Consultant, P.O. Box 4120, Arcata, CA 95521	
Tom MacFarlane	Humboldt State Univ., Psychology, Arcata, CA 95521	707-826-3740 707-826-3755 707-839-0689
Corinne A. Esser	CA Dept. Food/Agriculture, Long Range Planning, 1220 N Street, Rm. 104, Sacramento, CA 95814	916-445-8614
Robert D. Nelson	USFS Shasta-Trinity National Forest, Engineering, 2400 Washington Avenue, Redding, CA 96001	916-246-5361
Don Kaneko	USFS, Engineering/Geometronics, 630 Sansome St., San Francisco, CA 94111	FTS8-556-3476
Jack R. Fisher	USFS Shasta-Trinity National Forest, Watershed Management, 2400 Washington Ave., Redding, CA 96001	916-246-5304 FTS 241-5304

Name	Agency/Address	Phone
Chris Erikson	Trinity Co. Planning Dept., P.O. Box 936, Weaverville, CA 96093	916-623-5594
John J. Summerly	CA Dept. Parks & Recreation, Operations Div. 3431 Fort Avenue, Eureka, CA 95501	707-443-4588
Tim Burton	Dept. Fish & Game, Wildlife Management, P.O. Box 183, Lewiston, CA 96052	916-778-3913
Gary Monroe	Dept. Fish & Game, Wildlife Management, 619 Second St., Eureka, CA 95501	707-443-6771
Ray Flynn	Humboldt County Assessor, County Courthouse, Eureka, CA 95501	707-445-7491
Donald C. Tuttle	Humboldt County Dept. of Public Works, 1106 Second St., Eureka, CA 95501	707-445-7741
Stan Mansfield	Humboldt County Planning Director, 520 E St., Eureka, CA 95501	707-445-7541
Dale L. Wierman	CA Dept. of Forestry, FRAP Section, 1416 Ninth St., Sacramento, CA 95814	916-322-1945
Don Jones	Redwood Comm. Develop. Council, P.O. Box 323, Arcata, CA 95521	707-826-3731
Jack Naylor	Aero-Marine Research, 1690 Victor, Arcata, CA 95521	707-442-0359
Jay Wechselberger	USFS Hayfork Ranger Dist., P.O. Box 159, Hayfork, CA 96041	916-628-5227
Ron O'Hanlon	Bureau of Land Management, Forestry Dept., 355 Hemsted, Redding, CA 96001	916-246-5325
Randy Ferrin	USFS Six Rivers National Forest, Land Management Planning, 507 F Street, Eureka, CA 95501	707-442-1721
Lawrence Fox	Humboldt State Univeristy, Forestry Dept., Arcata, CA 95521	707-826-4873
Ken Mayer	US Fish & Wildlife Serv., Fisheries Div., c/o Humboldt State Univ., Center for Comm. Develop., Remote Sensing Project, Arcata, CA 95521	707-826-3731
James R. Anderson	USGS National Center, 12201 Sunrise Valley Dr., Reston, VA 22092	703-860-6344
Shari Wall	Remote Sensing Lab., Rm. 129 Mulford Hall, UC Berkeley, Berkeley, CA 94720	415-642-2351
Stephen DeGloria	Remote Sensing Lab., Rm. 129 Mulford Hall, UC Berkeley, Berkeley, CA 94720	415-642-2351
Sue Norman	CA Coordinator WRAP, NASA Ames Research Ctr., Mail Stop 242-4, Moffett Field, CA 94035	415-965-5899
Dale Lumb	NASA Ames Research Ctr., Mail Stop 242-4, Moffett Field, CA 94035	415-965-5900

Name	Agency/Address	Phone
Lucy Williams	CA Environmental Data Ctr., Office of Planning and Research, 1400 Tenth St., Sacramento, CA 95814	916-322-3784
Sally Bay Cornwell	Director, CA Environmental Data Ctr., Office of Planning and Research, 1400 Tenth St., Sacramento, CA 95814	916-322-3784
Joseph Webster	Humboldt State University, Center for Community Development, Remote Sensing Project, Arcata, CA 95521	707-826-3731
Donna Hankins	Project Director, Humboldt State University, Remote Sensing Project, Ctr. for Community Develop., Arcata, CA 95521	707-826-3731
Kamila Plesmid	Humboldt State Univ., Remote Sensing Project, Ctr. for Community Develop., Arcata, CA 95521	707-826-3731

7. Are there barriers to obtaining these needed items? Y ____ N ____
What are these barriers?

8. Are your job or division map and photo needs different than the overall agency needs? Y ____ N ____ If Yes, how are they different?

9. Can you take advantage of other agencies' mapping efforts? Y ____ N ____
Is this a practice in your agency or business? Y ____ N ____

10. Where do you usually obtain the maps you use?

11. Where do you usually obtain the photography you use?

12. What legislation, regulation or general practice determines your current map and photo needs?

APPENDIX C

SUMMARY SHEET

Based on input you have received in this workshop, list up to five actions that you believe should take place to fill the map, photography or special product needs of Northern California agencies and/or private sector groups.

Consider: What agency or group can provide the needed items?
Priority items developed here.
Common needs.
Cooperative methods that can be used to fill needs.

List Action Items here	Priority	Pro	Con
#1			
#2			
#3			
#4			
#5			

APPENDIX B

(ANOTHER)
QUESTIONNAIRE

We appreciate your time and effort to fill this out as completely and thoroughly as possible. It will help in understanding what is really needed by the people who are doing the work.

Representing: (agency) ____________________ Division or section: __________

Name: ____________________________ Phone: ________________________

Address: ________________________

____

____

1. What maps and map scales do you use in your specific work?

2. What photography and photo scale do you use in your specific work?

3. What are the principal uses of these maps and photos?

4. How often do you require updating of map and photo products?

5. What maps, photography or other products would make your specific job easier or better? Geographic area ________________
   Type. Land Use ________ Land Cover __________ Other ____________________
   Scale ________________ Color _____ Black/White ________ IR __________

6. Do these maps exist already? Y ____ N ____ Is the photography available? Y ____ N ____

APPENDIX IV

Documentation: Examples of Some Media Developed for Communications as Part of Grant Activities

* "Down-to-Earth Careers in Remote Sensing" Career Development Brochure
* "Signature" Newsletter
* "Evaluation of Remote Sensing Technology Transfer Simulation and Games"
* "Remote Sensing - a Valuable Career Tool" Career Development Workshop Flyer

REMOTE SENSING IS CREATIVE

You can approach a career or training in environmental remote sensing from two different directions First you can complete a course of study in the sciences or arts and then add remote sensing technology to the career emphasis Or you can begin with the technical training in photogrammetry, surveying, cartography, and computer science and then apply that knowledge to one or more disciplines In either case you should acquire a broad background that includes the fundamental concepts of remote sensing and underscores remote sensing's applications

In many ways, the more creatively you can relate to the technology, the greater is your career potential

REMOTE SENSING IS RELEVANT

The applications for remote sensing are growing all the time In January 1977 the National Aeronautics and Space Administration (NASA) initiated a new program to transfer remote sensing technology back to the public who supported its development

Three NASA regional application programs across the nation are helping state and federal agencies as well as local and state government people receive training in environmental remote sensing Through cooperative agreements with NASA and local universities, these people are exploring ways to efficiently compile resource inventories and build resource information systems

Because of this new national focus on technology transfer, remote sensing is a relevant and valuable career tool for today and tomorrow

REMOTE SENSING IS GENERAL AND SPECIFIC

The number of university remote sensing centers across the country has increased in the past ten years Where the past emphasis was on research, today the goal of these programs is the application of remote sensing to real-life problems

Advanced degrees in remote sensing are usually in conjunction with a discipline field, but an even broader background in natural resources and earth sciences may be the requirement of the future The "general" specialist finds a ready place in environmental remote sensing

For more information on graduate programs in remote sensing contact

Space Sciences Laboratory
University of California, Berkeley
Berkeley, CA 95720

Environmental Remote Sensing Applications Laboratory (ERSAL)
Oregon State University
Corvallis, Oregon 97331

Committee on Remote Sensing
University of Arizona
Tucson, Arizona 85721

For more information on the NASA Technology Transfer Program contact

Western Regional Applications Program (WRAP)
Mail Stop 242-4
NASA Ames Research Center
Moffet Field, CA 94035

Remote Sensing and Technology Transfer Project
Center for Community Development
Humboldt State University
Arcata, CA 95521

Down-to-Earth CAREERS *in* REMOTE SENSING

There is an ever-increasing world need for more accurate information about the earth--precise, fast, and in greater detail than ever before This need has created a new focus on remote sensing technology and on the people with remote sensing skills

REMOTE SENSING IS FAR-REACHING

Although many devices, including our own senses, are "remote sensors," remote sensing commonly describes the application and interpretation of low and high altitude aerial photography and satellite data for earth resource investigation

Until recently remote sensing was synonymous with photo interpretation, but improved aerospace technology has expanded remote sensing's scope to include computer technology Two earth resource satellites, Landsat 1 and Landsat 2 (to be joined shortly by Landsat 3) are sensing vast amounts of information about the earth every day and relaying that data to earth in computer-compatible form

As "automated image interpretation" of Landsat data becomes more common in resource management, greater demands will be placed on the person with remote sensing skills Although Landsat is automated, it is not automatic Proper interpretation and analysis of the data only emerges when the computer processor checks the work with aerial photography, maps, and field collections

REMOTE SENSING IS VERSATILE

Remote sensing is only a tool, but it has applications in almost every career or profession concerned with the environment

For the geographer or cartographer, remote sensing gives a view of the earth never imagined on the ground New areas are mapped, old areas are better understood Work is underway today to update existing maps with aerial photo overlays and create new maps with satellite imagery and data processing

For the forester, remote sensing facilitates harvesting and reforestation plans Foresters have long used low altitude aerial photography to manage timber stands Landsat can help assess an entire forest for long-range planning

The geologist uses remote sensing to observe fault systems and locate mineral and fossil fuel deposits that often occur along a fault The broad coverage of the Landsat image helps "lift" a fault line out of the ground features

The agriculturalist judges crop yield or crop damage from aerial photography and Landsat data Because Landsat is computer-compatible, statistics on crops are readily available

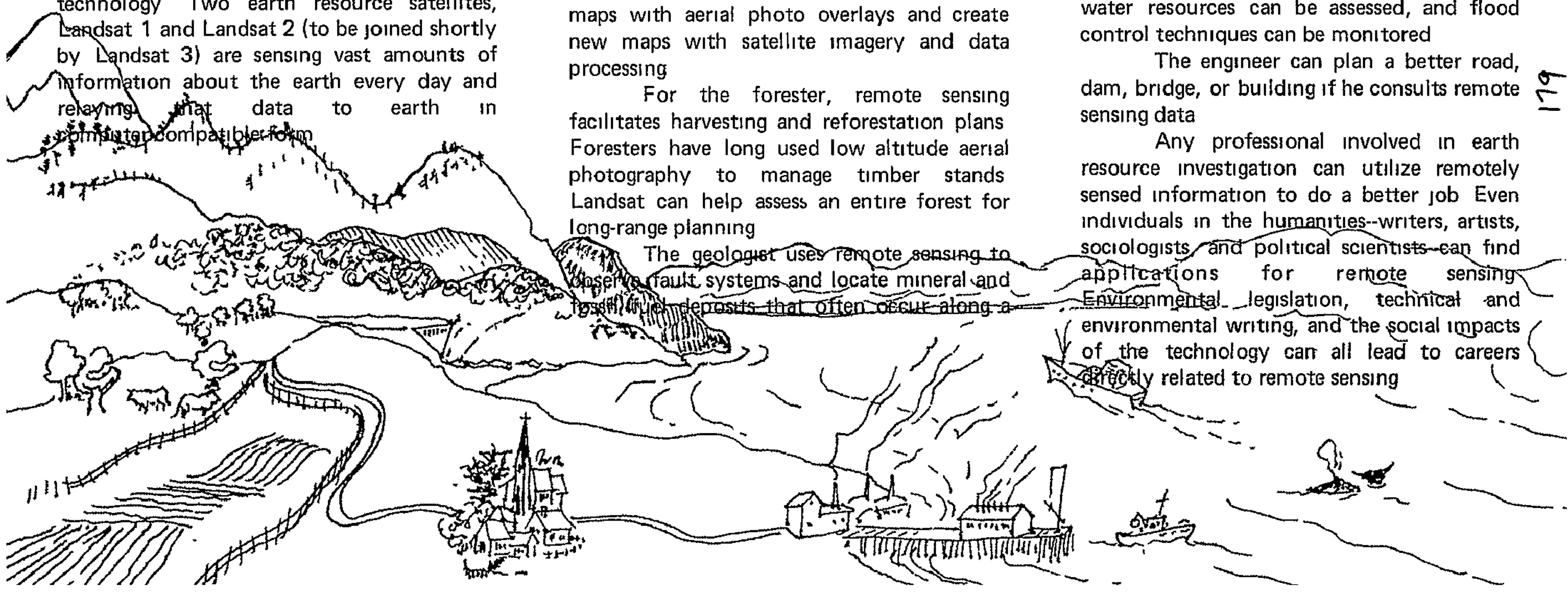
The environmentalist detects oil slicks and the off-shore dumping of waste using high altitude photography and satellite imagery--while the oceanographer studies ocean currents, upwelling areas, and bay and coastal environments from weather satellites and infared photography

For the planner, remote sensing tools help to map urban and agricultural land use for the future growth of an area Here all forms of aerial photography and Landsat data help the planner see the whole picture

Remote sensing helps the meteorologist and the hydrologist Meteorological events can be investigated, water resources can be assessed, and flood control techniques can be monitored

The engineer can plan a better road, dam, bridge, or building if he consults remote sensing data

Any professional involved in earth resource investigation can utilize remotely sensed information to do a better job Even individuals in the humanities--writers, artists, sociologists, and political scientists--can find applications for remote sensing Environmental legislation, technical and environmental writing, and the social impacts of the technology can all lead to careers directly related to remote sensing



NORTHERN CALIFORNIA
Signature
NASA GRANT NSG-2244

VOL. 1 NO. 1 SEPT. – OCT. 1977

EDITOR'S NOTE

The first issue of Signature is an introduction to the transfer of remote sensing technology and to the Northern California Technology Transfer Project. Subsequent issues will deal more specifically with how the technology is being applied in northern California, throughout the state, and in other western states. Signature's goal is never to lose sight of the real problems and concerns of people using the technology.

REMOTE SENSING REACHES THE REDWOOD EMPIRE

What began as a local citizens' effort three years ago may well become the model for other communities across the country to use space technology in solving land use and resource management problems. The Northern California Remote Sensing and Technology Transfer Project in Humboldt County is the outcome of a community need and a shift in the governmental policy towards public involvement in remote sensing.

In a dynamic effort this year, the National Aeronautics and Space Administration (NASA) is broadening its chartered scope of commitment. In addition to on-going research programs, NASA is making remote sensing technology readily available to the American public and training state and local agency personnel to really use the information. NASA, in an overall national transfer program, has divided the country into three geographical areas, each with a regional application program and a center. This regional approach, however, departs radically from the previous technology transfer patterns.

In the past, the expertise remained in the hands of highly-trained technicians, and no matter how much the user benefited from the results of the technology, he never acquired the ability to really absorb the technology into his everyday work. In a sense, the technician only helped the user for a day, rather than giving him tools he could use for a lifetime.

It was in the spirit of "tools for a lifetime" that the northern California remote sensing project was developed. At an action planning conference held in Eureka, California, in April, 1977, a plan emerged for a demonstration project to transfer remote sensing technology. As this project took shape, it became apparent that northern California, and in particular, Humboldt County, was an ideal environment for a grass roots approach to technology transfer. The ingredients for this choice were a small population with a natural resource-based economy, a state university with a large natural resources school, and a center for community development with initial ties between the university and the community of technology users.

High altitude image of Humboldt Bay, California.

GLOSSARY

(Remote sensing terms in this issue)

Cluster.	A group of Landsat picture elements which are very much "like" one another.
Footprint.	The field of view of a scanner at any one instant in time.
Imagery.	Visual representation of energy recorded by remote sensing instruments.
Landsat.	Satellite platform for electronic sensing devices that image the earth's surface.
Remote Sensing.	Sensing of objects or areas at a distance. Landsat detects reflected or emitted energy from the earth.
Scanner.	A device which assembles an image by moving a sensor across the viewed surface.
Signature.	A set of unique characteristics that serve to identify a feature by remote sensing.

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In June, 1977, a million and a half dollar NASA grant was awarded to Humboldt State University, through its Center for Community Development. The three year program will work towards a diverse group of technology users sharing a common source of remote sensing information. It also includes analysis of the remote sensing data.

Equally important to the northern California project is the framework for communication between NASA and all levels of public and private interests. On that issue, the project has the three years' experience of the Pacific Northwest Regional Commission (PNRC) and its Land Resources Inventory Demonstration Project (LRIDP) from which to draw. That project has been working closely with state agencies in Oregon Washington and Idaho. Because of similar land management problems, PNRC will be a valuable source of information to the northern California project.

Yet even as the northern California project hopes to gain the public's acceptance of remote sensing as an integral tool of land management, Director Donna B. Hankins emphasizes the need for constant evaluation of the impacts. "The real transfer of technology, whether it's in Humboldt County or anywhere else, will only succeed if the economic and social ramifications of the technology are addressed from the beginning."

The keys to the northern California project are a spirit of co-operation and flexibility. To develop an effective model for technology transfer will require a creative approach, perhaps as creative and dynamic as the technology itself. What NASA and the project hope to emerge is a plan for meeting the real needs of any community of technology users.

NORTHERN CALIFORNIA CLUSTER

(Reports on N.CA. demonstration projects)

A NEW APPROACH

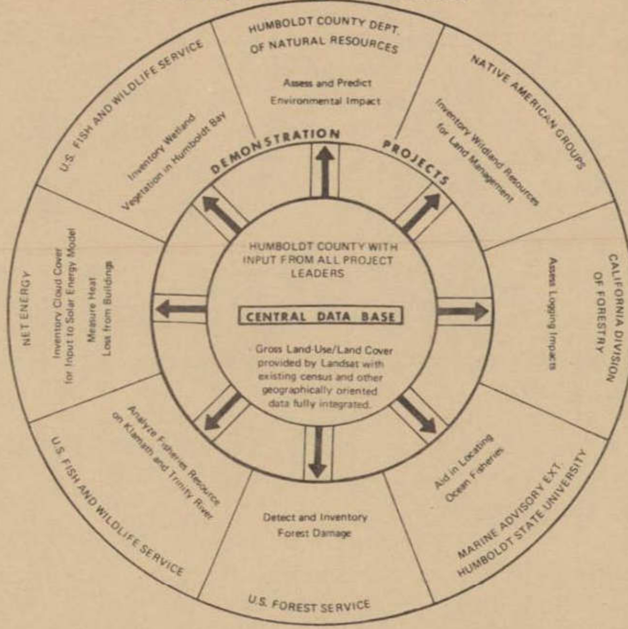
The staff of the Remote Sensing Technology Transfer Program is organizing a unique Landsat demonstration project in northern California. Many past efforts to transfer remote sensing technology from NASA to various government agencies have been discipline-oriented; that is, they have been forestry projects or agricultural projects or urban projects. By contrast, plans are being made in northern California to establish a central data base to be used by all disciplines.

The northern California project will rely heavily on basic categories of land cover that can be provided by Landsat: urban, agricultural, range, forest, brush, water, marsh, wet, riparian, and barren. In addition, Landsat will provide more detail within the above general categories. Urban land will be broken down into residential, commercial, and open land, for example.

Some specific data needs of the participating project members will not be obtainable from Landsat alone. Landsat will be used in conjunction with low and high altitude aircraft photography. The final data base will be expanded to include census data, topographic information and other geographic data which is already in existence.

Since many organizations will benefit from a single data base, it is important that they all share in the collection of support aircraft and ground information. For example, information obtained in our project on the forests of the region will be used by tribal and county governments and other regional planning groups as well as by the traditional forestry agencies such as U.S. Forest Service and California

Project plans for Landsat data.



Department of Forestry. These groups and others have indicated a willingness to coordinate their collection efforts to insure the accuracy and usefulness of the central data base.

The initial products of the demonstration project will be a series of functional overlay maps to demonstrate the utility of Landsat data. However, the long-term goal is a fully computerized system from which any category of land cover or group of categories can be extracted. This information could then be printed on a base map and listed on a table of total land area in each category.

Ultimately, the northern California project will be more than a collection of discipline-oriented plans. It will be a cooperative attempt by various citizen groups and government agencies to produce a data base which will be of great value to them all.

--Lawrence Fox
Technical Coordinator, N.CA. Project

CALIFORNIA FOOTPRINTS

(News of California remote sensing programs)

MENDOCINO COUNTY FUEL MANAGEMENT PROGRAM

In a cooperative agreement between Mendocino County and the Remote Sensing Research Program of the University of California at Berkeley, Landsat is being used to develop a program of wildland fire prevention and range management improvement.

Efforts for a control burn agreement between agencies and private landowners began two years ago with the formation of a Fuel Control and Land Management Committee, a cross section of public and private interests. But it wasn't until last fall that NASA grant money made it possible to involve remote sensing in the plan.

This summer a pilot project was completed in the Round Valley area of northeastern Mendocino. Ten categories of vegetation were broken out, using Landsat digital data, with an aim towards pinpointing the area of heaviest brush buildup.

That base information, as well as more conventional cartographic data, was then used by a cartographic unit of the Fuel Control Committee to prepare a series of maps on the area. The unit produced mylar overlays of such specifics as soil types, topography, property ownership patterns, watershed units and other elements necessary to the development of a comprehensive overview of interrelated conditions, problems and dynamics of land management.

Although the cartographic unit's primary job was mapping, they conducted field checks and surveyed individual landowners for their attitudes towards cooperative land management. They will be continuing those activities in the next phase of the project since the Fuel Control Committee feels that private participation is critical to a successful control burn program.

The next step of this project will be to designate the most severe fire hazard areas and eventually conduct control burns.

At a presentation to the Mendocino County Board of Supervisors in August, George Hammond, chairman of the Fuel Control and Land Management Committee, emphasized that "the use of remote sensing goes beyond wildland fire prevention. We see it as a basic tool in improving Mendocino County's range and timber resources."

WRAP SCANNER

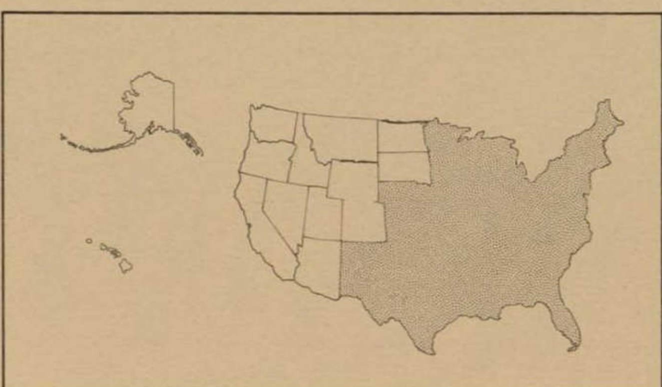
(Remote sensing activities in the 14 western states)

THE REGIONAL PROGRAM

The Western Regional Applications Program, (WRAP), is currently developing a long-range technology transfer plan for the 14 western states. (See page 1) Working through the Ames Research Center at Moffett Field, California, the program will focus on the individual and collective needs of a third of the nation. Although the region takes in a large geographical area, WRAP's director, Ben Padrick, hopes to structure an applications program that will stress the commonality of the technology users within those 14 states.

At a meeting earlier this year, a remote sensing task force of the National Conference of State Legislatures pointed out that satellite technology often fails to be transferred "to state and local governments due to flaws in the transfer process rather than in the technology." Their recommendation was a greater emphasis on effective communication links "between NASA and state and local governments; states with other states; state entitles within each state; and states with the private sector."

These recommendations seem to parallel the thinking of WRAP coordinators who were instrumental in NASA's funding of the northern California demonstration project. Since one aim of the project is to develop a communication model for technology transfer, WRAP planners will be evaluating the activities in northern California with an eye to incorporating some of those methods into the overall regional program.



An important component of the northern California project is technical training in the use of satellite imagery. For the project, that training will be accomplished jointly by Humboldt State University in Arcata, California, and by NASA, in a facility near Ames Research Center. While it is true that much of the technology transfer in the past has been between NASA and universities, the desire to train agency personnel, private citizens, as well as students and faculty members is a distinct departure from the past. The link, then, between NASA and the states may be greatly enhanced with the addition of "hands-on" training in remote sensing technology.

As WRAP planners work towards an effective applications program, they see the past transfer programs as guideposts. The dynamics of the technology demand a new approach to its transfer, one that will satisfy not only the needs of the 14 western states, but the rest of the nation as well.

Donna Hankins and project members at university reception.

IMAGES

(People profiles)

DONNA HANKINS

At a time when the emphasis of technology transfer is the user and his needs, Donna Hankins, director of the Northern California Remote Sensing and Technology Transfer Project, is a welcome sign.

What immediately impresses a person about Ms. Hankins is her enthusiasm and her energy. "She is a remarkable person," noted Ian McHarg, environmental designer/planner and author. "She has more energy than any one person I know." In part it is because of this exuberance and drive that agency personnel, county government officials, and private citizens are working together in northern California to build a community model for the use of satellite and aircraft imagery.

Of particular significance is the fact that Ms. Hankins is a nine year resident of Humboldt County and has always been involved in county concerns. She received her training in geology and hydrology at Humboldt State University and was formerly president of Pilot Rock, Inc., the pioneer business in the United States producing educational material on remote sensing.

Donna came to the attention of NASA through her association with a Humboldt County citizens' task force that was exploring the potentials of using space technology to answer county natural resource problems. At the time of that group's formation, Ms. Hankins held the belief that the best way to convey information to people with diverse interests was direct contact and individual follow-up.

That personal approach to the dissemination of information is what characterizes the northern California demonstration project and what also characterizes the plans for the transfer of remote sensing technology in the western states. To Ms. Hankins, the keys to building public trust and understanding of technology are openness with people and a willingness to involve them in the decision-making process.

In many eyes, the spirit and commitment of individuals like Donna Hankins is an insurance that the technology user will eventually be the technology driver and will determine how future technology can really meet his daily needs.

CAPITOL NOTES

Legislation that would fund a California experimental program for wildland fire protection, similar to the Mendocino County project, has met with problems in the State Ways and Means Committee. The bill, sponsored by Second District Assemblyman Barry Keene, proposes that two experimental areas in the state serve as models for a statewide cooperative burning plan. According to Liz McMahon, aide to Assemblyman Keene, Ways and Means questioned the initial expenditure for the program. Keene, however, is asking for reconsideration. To Keene, a protection plan now may save valuable acres in the future.

CALENDER FOR SEPTEMBER AND OCTOBER

(A list of presentations, workshops, and classes related to remote sensing and the northern California project.)

September

21-23 Remote Sensing Workshop at University of California at Berkeley. Contact Continuing Education in Environmental Design, (415) 642-4811.

26 Humboldt County Board of Supervisors' Study Session on the Northern California Technology Transfer Project.

October

28 Presentation at Eureka Southwest Rotary, 12 noon, Eureka Inn, Eureka, CA.

REMOTE SENSING TECHNOLOGY TRANSFER PROJECT — NASA

NORTHERN CALIFORNIA

Signature

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D Allow 20 to 30 minutes for the activity.

E. Discussion: Afterwards, with the entire group, discuss the following:

1. What kept you from solving the problem? (The problem could not be solved without the contribution of each person in the group.)
2. What helped you to solve the problem later? (It is easier to talk in a small group than in a large group.)
3. Was the way in which you listened in the beginning different from the way you listened in the end?
4. None of us is as smart as all of us.
5. The pieces of paper represent the information and skills that each person brings to a group.

III. Evaluation of Simulation and "6 - Bits". The Simulation and 2 types of "6 - Bits" (Murder Mystery and Manzanita Valley) were tested with a group of residents of the town of Mendocino. It was found that the game places too much emphasis on the process of reaching consensus, and not enough on remote sensing and its implications. The "6 - Bits" exercises were successful in creating a good problem-solving atmosphere.

The following recommendations are made for future use of these materials:

A. The entire simulation as is might be used for groups that have a good background in remote sensing, that are well organized, and that have a need for a problem-solving model to use in their resource-use conflicts. The simulation would fit in towards the end of a session or workshop in remote sensing technology.

B. Pieces of the simulation can be used where applicable. Some suggestions follow:

1. Have maps made of the local area (7 min. quad) and use these or use the map of Mink County in Appendix III in situations where a heated controversy over actual resource-use issues is imminent. Create a problem-solving exercise based upon either set of maps which would generate a list of information needs, and would prioritize these needs as in the NASA "Lost on the Moon" consensus game in Appendix IV.

   This would be useful towards the beginning of an information session in remote sensing after an introduction. It will bring to the participant's minds their particular information needs.

2 Large scale maps and map bases of Mink County can be used as visual aids in presentations.

3. Segments of the tape recording, e.g. logger's, farmer's, forest engineer's and environmentalist's speeches of Land Grab situation can be taken and used to make a more general tape of any situation where remote sensing technology can be used to help solve a resource problem. This can be used in conjunction with actual maps of a local area -- as in above exercise 1) or in the next exercise 4).

4. As part of a workshop for individuals having some background in remote sensing, the role cards can be used for a group discussion on the social implications of remote sensing technology. Individuals could select a role to play and discuss -- Do we want to use this technology? What restrictions should we place upon its use?

C. "6 - Bits" exercises can be used at the beginning of workshop sessions -- it emphasizes the need for sharing information. The "Murder Mystery" and "Manzanita Valley" "6 - Bits" can be used for any group. If more than 6 are playing, make additional copies of the exercise for each group of 6. The "Lake Erie" "6 - Bits" needs testing. It should be used by those with more of a technical orientation. Each of these exercises can be used as a model to make a "6 - Bits" exercise from any problem.

APPENDICES

APPENDIX 1 -- SAMPLE "6 - BITS"

Manzanita Valley

SIX-BITS VARIATION (A Problem-solving Technique)

1

Although you may tell your group what is on this slip, you may not pass it around for the others to read.

Fifty per cent of the areas of heavy brush build-up within the project area are privately owned.

Areas with the most serious fire hazard can be idenified with LANDSAT data.

Category A land has the heaviest brush build-up.

2

Although you may tell your group what is on this slip, you may not pass it around for the others to read.

The Manzanita Valley area was the site of a pilot project in remote sensing technology transfer.

Areas of heavy brush represent a serious fire hazard.

The long range goal of this project is cooperative land management.

3

Although you may tell your group what is on this slip, you may not pass it around for the others to read.

LANDSAT is a satellite platform for electronic sensing devices that image the earth's surface

Areas of heavy brush build-up can be identified using LANDSAT data.

Private participation is essential for a successful project.

4

Although you may tell your group what is on this slip, you may not pass it around for the others to read.

The Manzanita Valley contains 400,000 acres.

LANDSAT data is being used to develop a wildland fire prevention program.

Control burns can be conducted in areas of high fire danger.

5

Although you may tell your group what is on this slip, you may not pass it around for the others to read.

One fourth of the Manzanita Valley has been classified as Category A land.

LANDSAT data was used to identify 10 categories of vegetation within the project area.

Land ownership boundary lines are superimposed on the satellite imagery of the project area.

6

Although you may tell your group what is on this slip, you may not pass it around for the others to read.

Your group members have all the information needed to find the solution to the following problem. Only one answer is correct. Some of the information provided is not relevant and will not help solve the problem.

PROBLEM: How many acres of land in the project area representing serious fire danger are privately owned?

APPENDIX I -- SAMPLE "6 - BITS"

Murder Mystery

SIX-BITS VARIATION (A Problem-solving Technique)

1

Although you may tell your group what is on this slip, you may not pass it around for others to read

INFORMATION

Bills, the bookmaker, has been found dead in the club lounge, his wine poisoned

The murderer's hand stealthily moves forward to put something in Jones' Whiskey

No one has left his seat and there is no one else in the room.

2

Although you may tell your group what is on this slip, you may not pass it around for others to read.

INFORMATION

Four men are sitting on a sofa and two chairs, which are on either side of the sofa, in front of the fireplace

The four men's names are Smith, Brown, Jones and Robinson.

Smith is sitting in one of the armchairs The Schoolmaster is next to him on his left.

3

Although you may tell your group what is on this slip, you may not pass it around for others to read

INFORMATION

The four men are, not necessarily respectively, a general, schoolmaster, admiral, and doctor

The schoolmaster is a teetotaler

4

Although you may tell your group what is on this slip, you may not pass it around for others to read.

INFORMATION·

There is a mirror over the fireplace.

Your group members have all the information needed to find the answer to the following question Only one answer is correct You can prove it

PROBLEM What is the profession of each man, and where is he sitting? Who is the murderer?

5

Although you may tell your group what is on this slip, you may not pass it around for others to read

INFORMATION

The waiter pours a glass of whiskey for Jones, and a beer for Brown.

Neither Smith nor Brown has any sisters

Smith is the Admiral's brother-in-law.

6

Although you may tell your group what is on this slip, you may not pass it around for others to read

INFORMATION

The General looks up, and in the mirror over the fireplace, sees the door close behind the waiter He then turns to speak to Robinson who is next to him

[illegible]

Lake Erie

SIX-BITS VARIATION (A Problem-solving Technique)

1

You may tell the others what is on this card, but you may not pass it around.

- You are a remote sensing technology transfer regional user from Michigan/Ohio Department of Public Works
- You have at your disposal much data about human usage of the Lake, including waste disposal data and geography.
- Much of your information is outdated.
- Kelly and South Bass Islands are located Northeast of Port Clinton.
- Port Clinton's coordinates are 41.3°N82.9°W.
- Port Clinton has a growing population of 850,000
- A large steel company has its mill on the west shore of the rectangular Lake Erie.

2

You may tell the others what is on this card, but you may not pass it around.

- You are a low-flying aircraft photo interpreter.
- Thermal IR photography identified several zones of brightness in the lake on Sept. 5.
- These brighter zones extended from 41.5°N 82.8°W to 41.6°N82.6°W.
- Lakes Michigan, Huron, and Superior flow into Lake Erie at its Northwest point.

3

You may tell the others what is on this card, but you may not pass it around.

- You are a ground truther for remote sensing technologists. You determine the spectral signature for the resource being managed.
- You observed a large bloom of _Aphanizomen flos-aquae_ in the Utah Lake on July 14th.
- Algae is high reflective in near-infra-red.
- The surface water at Port Clinton was 14.5°C on September 5, 1975.

4

You may tell the others what is on this card, but you may not pass it around.

- You are a computer analyst, working to integrate satellite data.
- Satellites can monitor subtle alterations in the environment which normally remain unperceived.
- On July 14 a satellite flight over Utah Lake revealed a large gyre in the lake on bands 5 and 6.
- LANDSAT revealed zones of cyclonic traces in Lake Erie on Spetember 8 in the red band and near-infra-red band.

5

You may tell the others what is on this card, but you may not pass it around.

- You are a U-2 aircraft photo interpreter.
- Using multi-band photos, you notice that the gyres reverse contrast with surrounding water in the near IR
- During a routine flight over Lake Erie on Sept. 8, a long dark streamer was observed between the Islands.
- On Sept. 9, a special flight confirmed the sighting and revealed a second streamer directly below the inflow channel into Lake Erie.

6

You may tell the others what is on this card, but you may not pass it around.

- You are the limnologist from the Water Quality Control Board of the Great Lakes Area.
- Summer algae blooms make regular appearances in Lake Erie.
- The evolution of most blooms takes place in two to three days.
- Your group has a problem to solve.

PROBLEM: Which areas of the lake are likely to have algae blooms?

APPENDIX II

REMOTE SENSING TECHNOLOGY TRANSFER SIMULATION GAME

RULES

Note: First play "6 - Bits"

1. This game simulates an idealized resource management issue where citizens of a county are returned a substantial amount of decision-making power. Citizens and resource agency representatives, together, try to find the best solutions to the hypothetical issues in the game.
2. The first object of the game is to reach a consensus solution; one solution with which all players can agree. It is the process that is important, though, not the final solution.
3. The second object of the game is to give you a chance to explore the social implications of remote sensing as a resource management tool as you try to solve an issue in resource management.
4. Now, divide yourselves equally into 5 groups. Each group will represent one of these interest groups: recreationists, social reformers, landowners, business persons, and government agencies. (Have participants select the group they prefer.)
5. We believe that playing the role of someone different than yourself will give you a new perspective on the issues Act the way you believe persons who actually find themselves in such roles would act. These role cards are only a beginning. Feel free to expand upon your role in any way you wish. Improvise. (Pass out cards. Wait. Pass paper and pencils.)
6. After the introductory newscast.
   A. Each group will prepare a short general statement of their position.
   B. Present them at a public forum.
   C. Short discussion.
   D. Back to old groups or form new groups and formulate specific plans of action.

FINAL PUBLIC FORUM -- Each group presents their alternatives.
DISCUSSION -- Try to reach consensus that integrates the various points of view. (30 minutes)
FORM CAUCUSES IF NEEDED.

7. Show slides, play tape.

8. Have someone give out consensus suggestions.

9. Begin -- each group will prepare a short general statement about their position on these issues.

   A. Which area should be selected? (10,000 acres)

   B. How should it be used?

   C How should we use the information provided by NASA?

10. Each group presents positions and discuss.

11. Back to old groups, or form caucuses in order to draw up a specific plan of action on these issues. To assist you, NASA has made available sample maps of the area containing remote sensing data. Each group gets one and a list of the others available at any time you can use these maps collectively. (Pass maps and map lists.) Use this information, draw your own maps of the area you'd like to see acquired and develop a strategy to present plan.

12. Public Forum. Groups present, discuss.

13. Give court suit card

14. Try to reach a consensus in 30 minutes that integrates the different points of view.

Questions for Discussion:

1. Call attention to unanswered questions (describe and analyze what went on). Jot down notes during game, pertinent phrases.

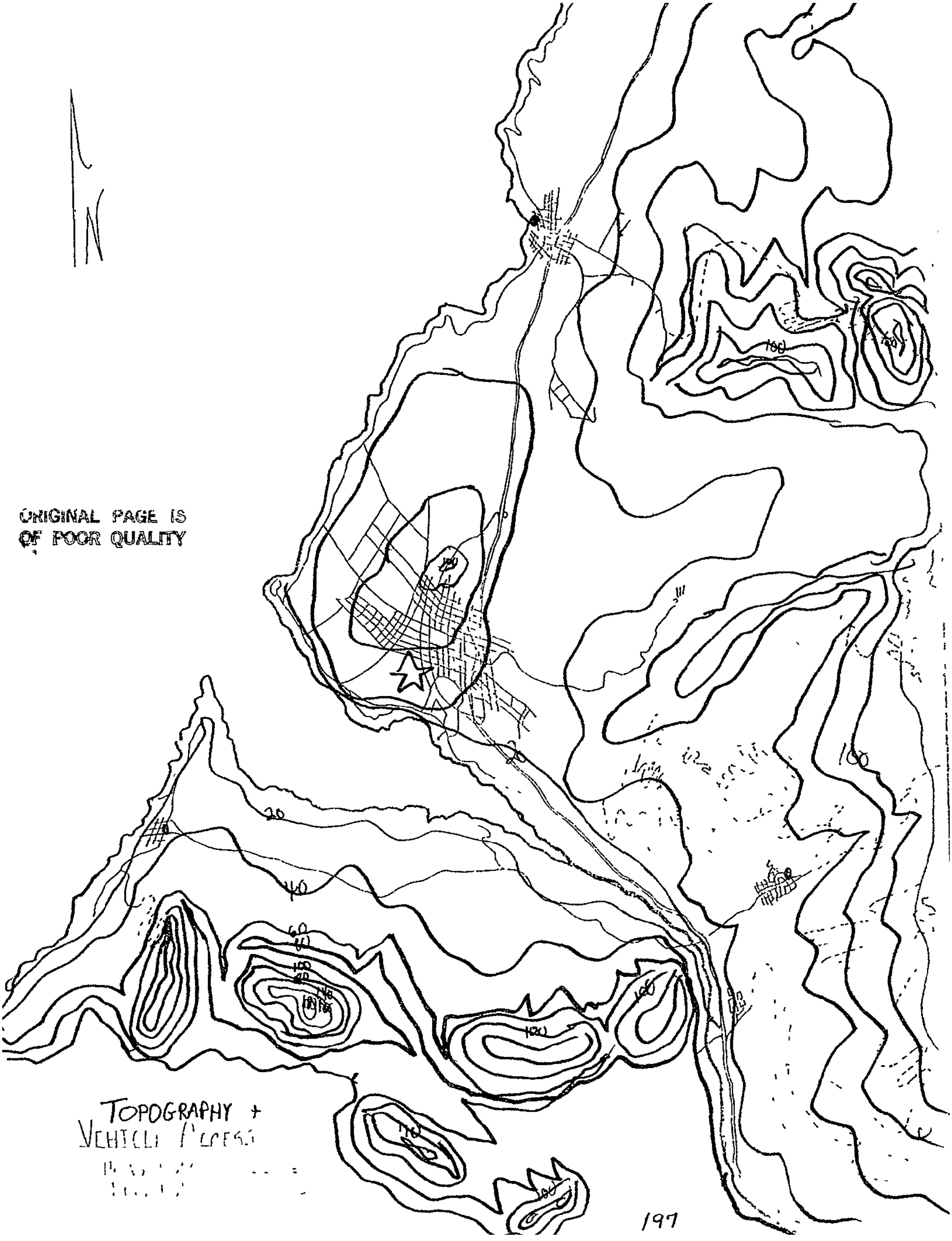
2. Get players to suggest applications of this game in real life. How does this relate to real life situations?

3. What sorts of additional information did you need in order to solve these issues?

4. How could remote sensing data be used in this area? What restrictions should be placed on this area? Who are the key representatives and who are the key agencies who should be involved in training sessions?
5. Could this kind of community decision-making really work? What has to happen first?
6. Feedback loop -- send any ideas back to us about game itself, or about the use of remote sensing data.
7. What is the next step?

APPENDIX III

Set of 6 maps of Mink County for a Problem-solving Exercise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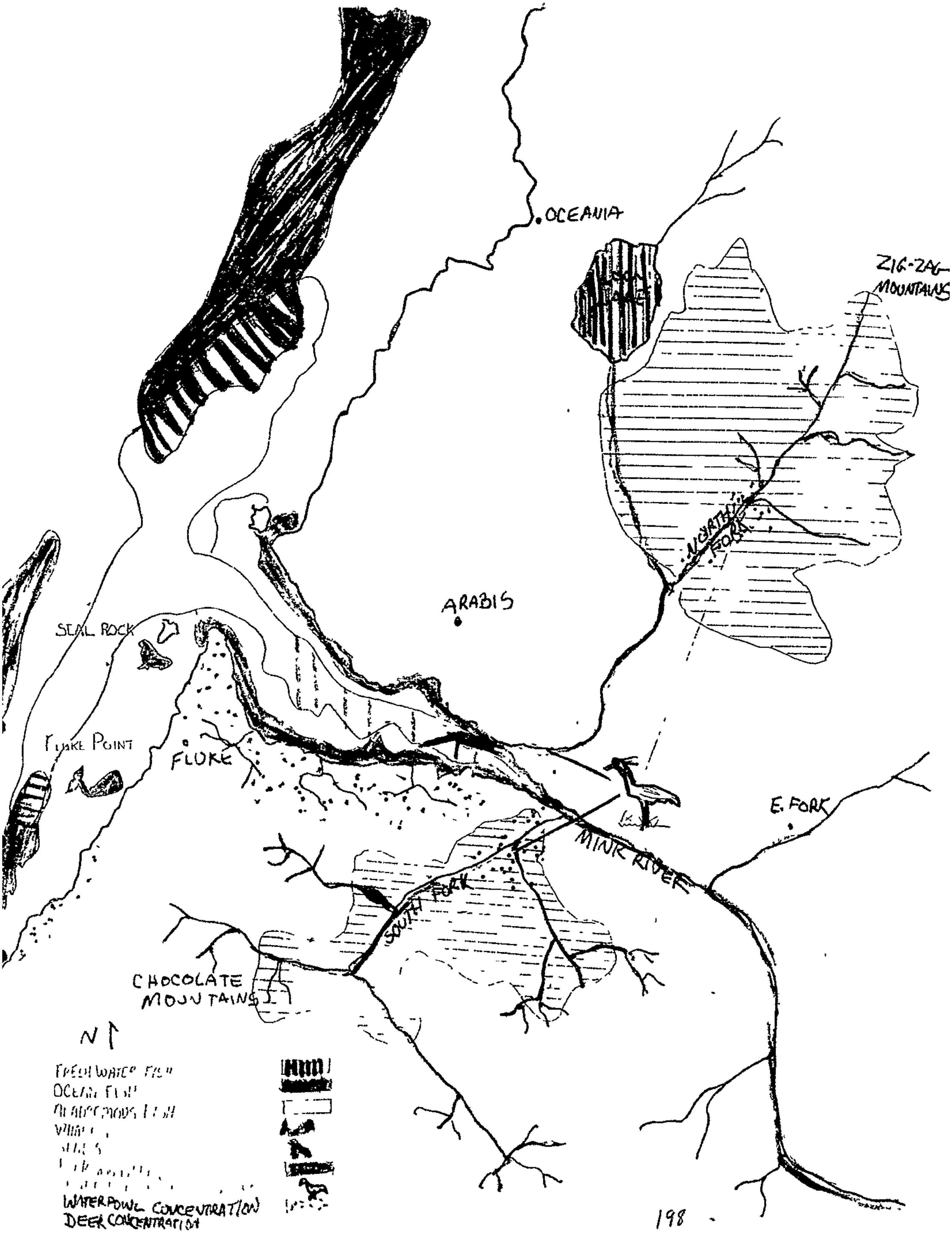

OCEANIA
ZIG-ZAG MOUNTAINS
ARABIS
NORTH FORK
SEAL ROCK
FLUKE POINT
FLUKE
E. FORK
MINK RIVER
SOUTH FORK
CHOCOLATE MOUNTAINS
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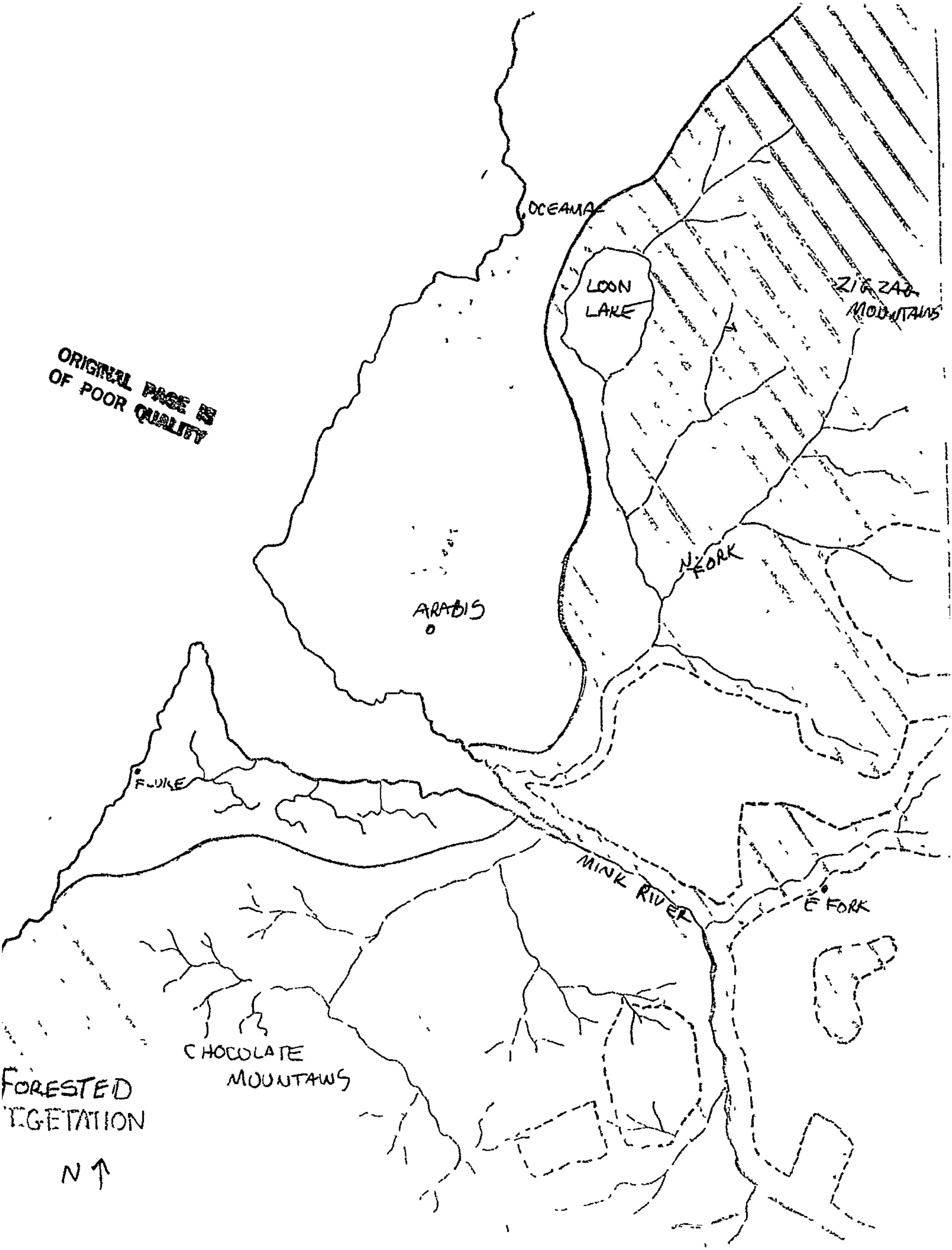
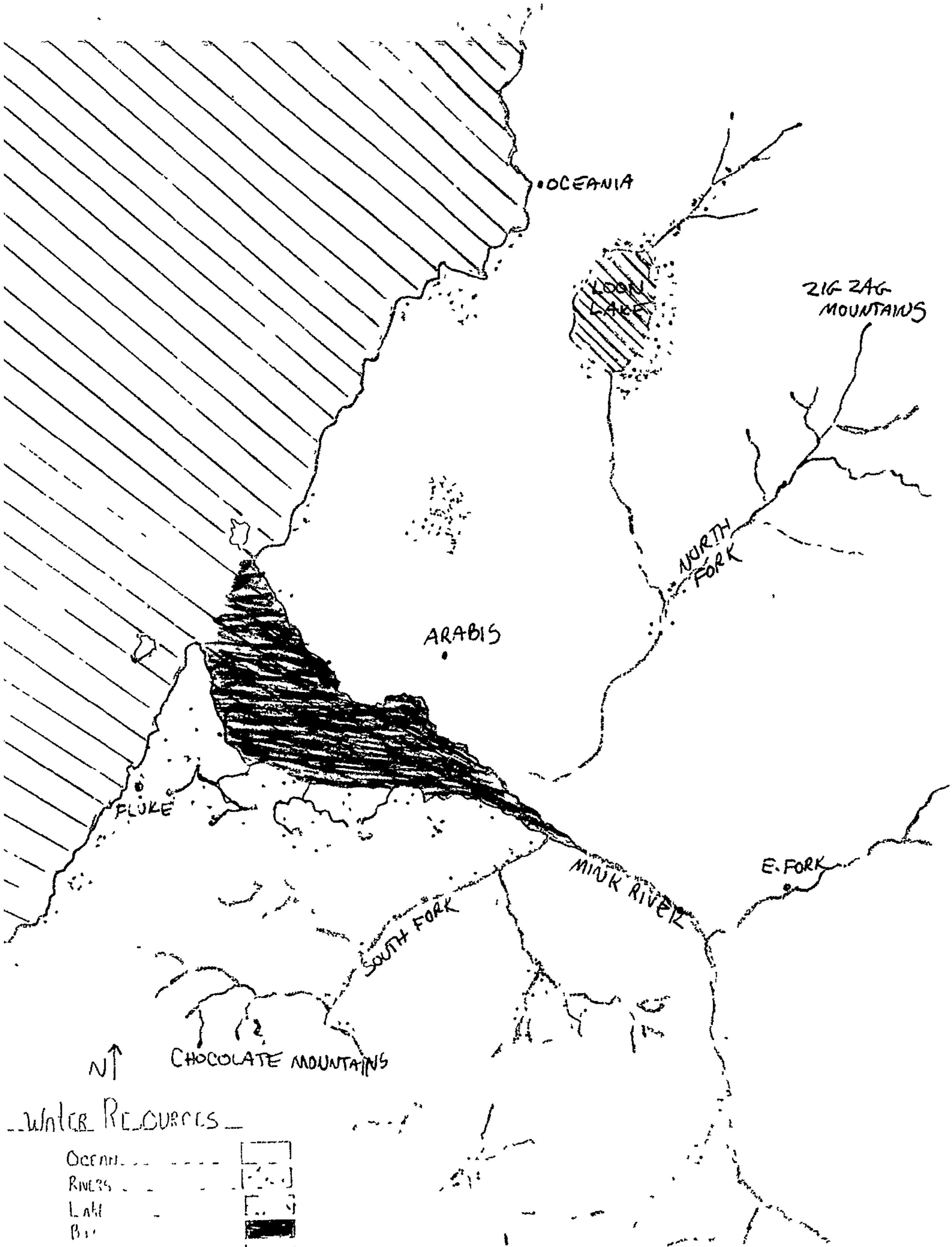
FRESHWATER FISH
OCEAN FISH
WATERFOWL CONCENTRATION
DEER CONCENTRATION



FORESTED VEGETATION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SOUTH FORK
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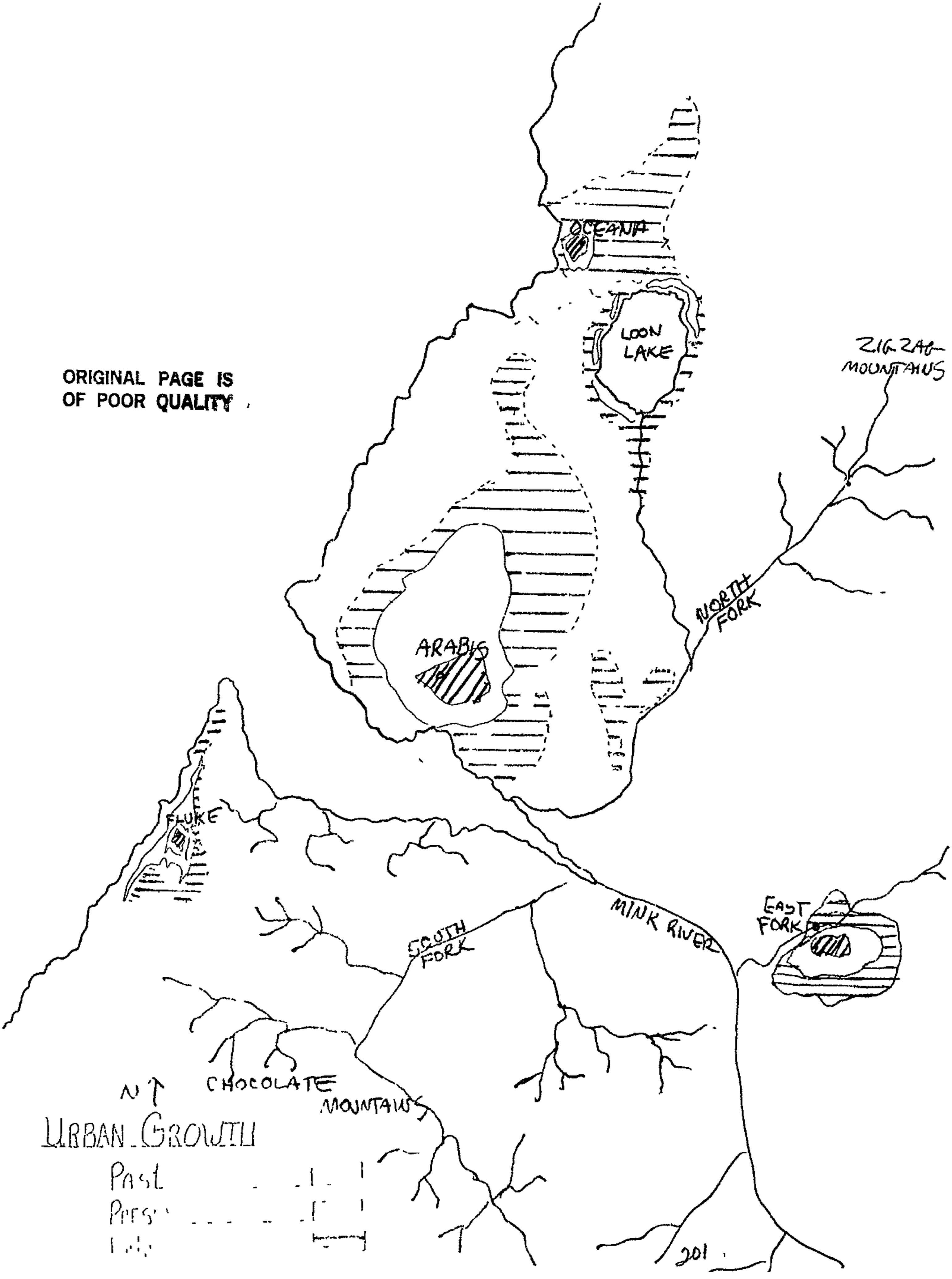
Water Resources
Ocean
Rivers
Lake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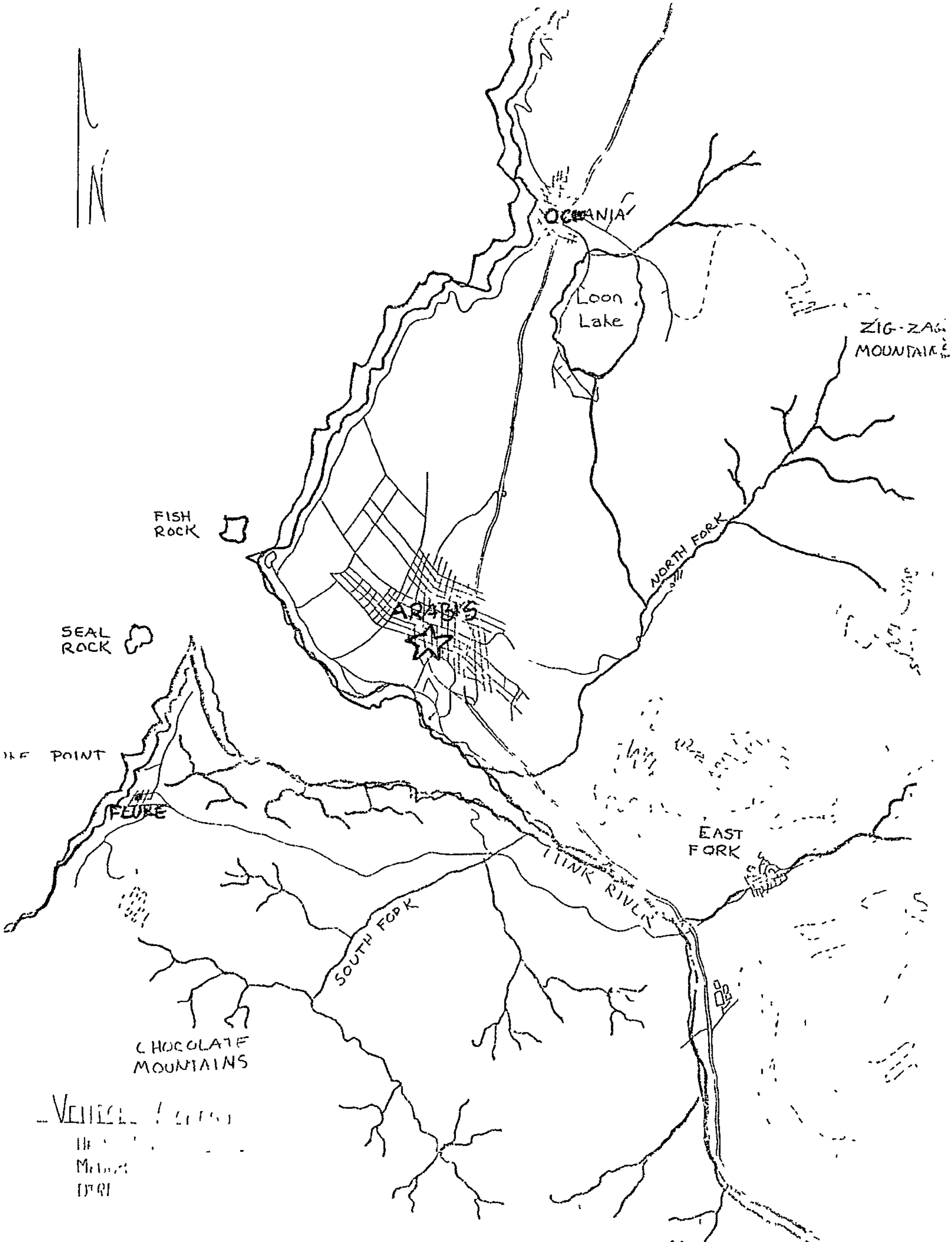
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ZIG-ZAG MOUNTAINS
FISH ROCK
SEAL ROCK
NORTH FORK
ARABI'S
POINT
EAST FORK
LINK RIVER
SOUTH FORK
CHOCOLATE MOUNTAINS

APPENDIX IV

Priotizing Consensus Game Model

Decision by Consensus

Aim: Experiencing how group decisions are made and how groups can work together to solve a common problem. Experiencing and illustrating a novel. Becomming aware of group interaction and how to function better in a group situation.

Format: NASA

First section (to be taken by individuals). Instructions:

You are in a space crew originally scheduled to rendezvous with a mother ship on the lighted surface of the moon. Mechanical difficulties, however, have forced your ship to crash-land at a spot some 200 miles from the rendezvous point. The rough landing damaged much of the equipment aboard. Since survival depends upon reaching the mother ship, the most critical items available must be chosen for the 200 mile trip. Below are listed the fifteen items left intact after landing. Your task is to rank them in terms of their importance to your crew in its attempt to reach the rendezvous point. Place number one by the most important item, number two by the second most important, etc. through fifteen, the least important.

_______box of matches
_______food concentrate
_______50 feet of nylon rope
_______parachute silk
_______portable heating unit
_______two .45 caliber pistols
_______one case dehydrated milk
_______two one-hundred pound tanks of oxygen
_______stellar-map (on the moon's constellation)
_______life raft
_______magnetic compass
_______five gallons of water
_______signal flares
_______first-aid kit containing injection needles
_______solar-powered FM receiver-transmitter

11/14/74

NASA (Cont.)

Second Section (group consensus) This is an exercise in group decision-making. Your group is to employ the method of group concensus in reaching its decision. This means that the prediction for each of the fifteen survival items must be agreed upon by each group member before it becomes ~~a part of the group decision.~~ Concensus ~~is difficult to reach.~~ Therefore, not every ranking will meet with everyone's complete approval. Try, as a group, to make each ranking one with which all group members can at least partially agree. Here are some guides to use in reaching consensus:

1. Avoid arguing for your own individual judgments. Approach the task on the basis of logic.

2. Avoid changing your mind only in order to reach agreement and eliminate conflict. Support only solutions with which you are able to agree to some extent, at least.

3. Avoid conflict-reducing techniques such as majority vote, averaging, or trading ~~in reaching decisions.~~

4. View differences of opinion as helpful rather than as a hindrance in decision-making.
Conflicts are a necessary step in realizing one's interests

On the Group Summary Sheet place the individual rankings made earlier by each group member. Take as much time as you need in reaching your group decision.

Key: Take the difference between your ranking and the ranking on the key. Add the differences. The lower the score the better. These answers are based on the best judgments that are now available to you. They are not absolute answers.

Third Section: (critique) Following the exercise, discuss the sources of the problem-solving techniques. How often did individuals use the affective domain in working out the problem? How often did the cognitive domain dominate? What kind of balance existed? How did their knowledge of the extensional world allow them to work with the unknowns? What did they learn about their own learning styles? Did they work better in groups or alone? Did they score higher as a group, or was the individual score better? How did the scores compare with the group average? Did they enjoy the individual work more than the group work?

Fourth Section (applicability) Compare with the group problems experienced by the boys in the novel Lord of the Flies.

11/25/74

ORANGE COUNTY DEPARTMENT OF EDUCATION
DRUG ABUSE PREVENTION EDUCATION CENTER

LOST ON THE MOON

ANSWER SHEET

Items	NASA's Reasoning	NASA's Ranks	Your Ranks	Error Points	Group Ranks	Error Points
ox of matches	No oxygen on moon to sustain flame; virtually worthless	15				
ood concentrate	Efficient means of supplying energy requirements	4				
fty feet of nylon rope	Useful in scaling cliffs, tying injured together	6				
arachute silk	Protection from sun's rays	8				
olar-powered portable eating unit	Not needed unless on dark side	13				
wo 45 caliber pistols	Possible means of self-propulsion	11				
ne case of dehydrated [illegible]	Bulkier duplication of food concentrate	12				
wo 100-pound tanks of [illegible]	Most pressing survival need	1				
tellar map (of the [illegible])	Primary means of [illegible]	3				
elf-inflating life raft	CO bottle in military raft may be used for propulsion	9				
agnetic compass	Magnetic field on moon is not polarized, worthless for navigation	14				
ve gallons of water	Replacement for tremendous liquid loss on lighted side	2				
ignal flares	Distress signal when mother ship is sight	10				
irst aid kit containing njection needles	Needles for vitamins, medicines, etc. will fit special aperture in NASA space suit	7				
olar-powered FM receiver-transmitter	For communication with mother ship, but FM requires line-of-sight transmission and short ranges	5				
		TOTAL				

rror points are the absolute difference between your ranks and NASA's (disregard plus or minus signs)

Scoring for individuals

0-25 = excellent
26-32= good
33-45= average
46-55- fair
56-70 = poor
71-112= very poor
Suggest possible faking or use of earth-bound logic

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EVALUATION FORM

Please answer each item as completely as possible.

1- Did you change your views to help arrive at a consensus of opinion? Where there some items which you refused to compromise on?

2- What made it difficult for you to reach a compromise? Would the same decision have been reached if you had not made a compromise?

3- Is the final consensus something that you yourself would have selected? Whose interests does it reflect? How far into the future do you feel you should project your considerations?

4- How do you feel about compromise as a means of resolving human and environmental needs? Is it an equitable means of resolving conflict? How does it compare with voting, and other decision-making methods?

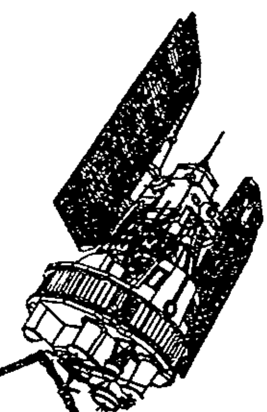
REMOTE SENSING

-A VALUABLE CAREER TOOL-

TUESDAY FEBRUARY 7

U.C. MULTIPURPOSE ROOM

12 NOON - 2 P.M.

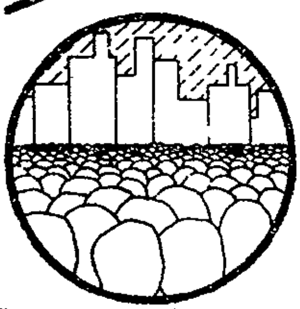


A CAREER DEVELOPMENT WORKSHOP

SPEAKERS:

DONNA HANKINS — NASA Project Director

LARRY FOX - Forestry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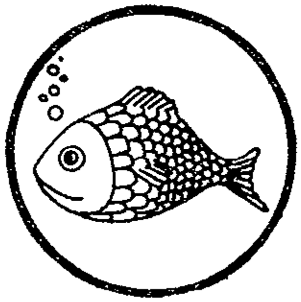
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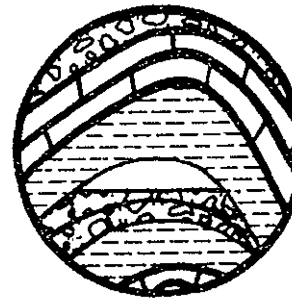
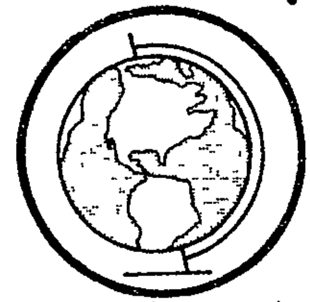
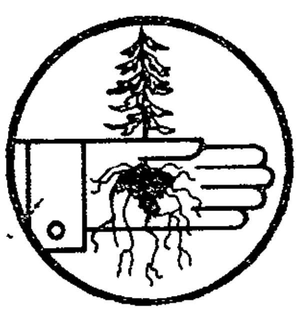
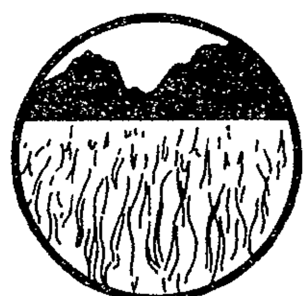
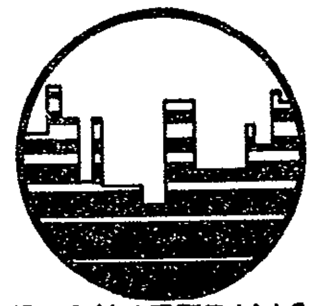

GEOLOGY


GEOGRAPHY


RPI

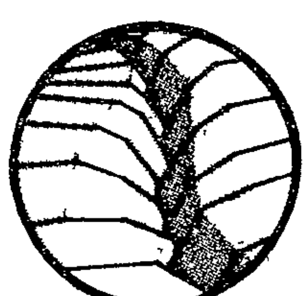

MATHEMATICS

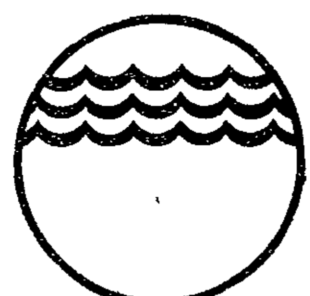

RANGE MGM'T.


ENGINEERING


FORESTRY


BIOLOGY


WATERSHED MGM'T.


OCEANOGRAPHY

APPENDIX V

Documentation: Hoopa Valley Indian Reservation Demonstration Projects as Part of Grant Activities

* Final Report -"Watershed Condition Inventory of the Hoopa Valley Indian Reservation Utilizing Landsat Digital Data" by Kenneth E. Mayer and Lawrence Fox III

* Executive Review of Final Report - "Watershed Condition Inventory of the Hoopa Valley Indian Reservation Utilizing Landsat Digital Data" by Donna B. Hankins

* Summary of Master's Thesis, "Evaluation of Deer Habitat on the Hoopa Indian Reservation, Northwestern California, Using Landsat Data Processed by Computer," by Jeffrey Soto

* "Summary of Yurok Photo Interpretation Class," by Jeff Soto

FINAL REPORT

Watershed Condition Inventory of the Hoopa Valley Indian Reservation Utilizing Landsat Digital Data

By

Kenneth E. Mayer and Lawrence Fox III

U.S. Fish and Wildlife Service
Arcata Field Station
Arcata, California

and

Remote Sensing
and Technology Transfer Project
Humboldt State University
Arcata, California

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ABSTRACT

Landsat digital data was analyzed using EDITOR software to map land condition and vegetative cover on the Hoopa Valley Indian Reservation in Northern California. Guided clustering was employed to identify the maximum number of spectral classes within the study area.

Land condition was mapped according to percent crown closure of brush (e.g. <10% to >80%) which was correlated to erosion potential. Vegetational communities were aggregated together and identified as either conifer, mixed (conifer, hardwood and brush) or hardwood.

Evaluation of the classification was completed using binomial approximation within a cluster sampling design. The overall mean probability of correct classification for omission and commission was 0.916 and 0.914 respectively.

The major conclusions are (1) Landsat digital data can provide accurate detailed information on land condition and vegetative cover in rugged mountainous terrain when analyzed using guided clustering techniques; (2) a successful classification requires reliable and adequate ground information, an interactive computer system with clustering capabilities and adequate time for re-training to increase classification accuracy; (3) It is possible to accurately classify a Landsat scene using a remote computer terminal linked by phone to a central computer. A color video display was not used for this classification.

PROJECT ADMINISTRATION

The project was a cooperative effort between the Remote Sensing and Technology Transfer Project (RSTTP) at Humboldt State University, the U.S. Fish and Wildlife Service (USFWS), and NASA Ames Research Center (ARC).

The RSTTP provided overall administrative and coordinating functions between the three agencies. Humboldt State University, through its Center for Community Development, provided office facilties for the RSTTP for the duration of the project. RSTTP was funded by the ARC-Western Regional Applications Program (WRAP), with a substantial portion of those funds set aside to complete this project.

NASA ARC provided:

- Technical coordination/consultation for all phases of the project
- Technical facilities and personnel for training of USFWS and HSU participants
- Computer facilties and analysis support materials
- Output product generation

U.S. Fish and Wildlife Service provided:

- Biological technician support (130 day position)
- Access to ground data in conjunction with the Bureau of Indian Affairs and Hoopa Indian Tribal Council, Hoopa, California
- Consultation and coordination of activities in collection of ground data and other supplementary materials.

ACKNOWLEDGEMENTS

Many people have contributed to the success of this project. Ms. Donna Hankins provided the impetus upon which this project was initiated and served as principal investigator for the RSTTP. We wish to thank Mr. Joseph Webster for his support and guidance. His editorial comments and administrative efforts are gratefully acknowledged.

Mr. Gary Rankel served as USFWS project director. His knowledge of fishery management was invaluable to the success of the project.

We wish to thank the many people that assisted us from the NASA, Ames Research Center. Dr. Dale Lumb, Ms. Sue Norman and Mr. Dave Peterson served as administrative and technical coordinators; a special thanks must be given to Mr. Buzz Slye for his technical expertise and to Mr. Don Card for advice on sampling design.

The U. S. Geological Survey Geography Program at NASA, Ames, contributed substantially to the computer analysis phase of the project. Especially important contributions were made by Mr. William Newland and Mr. Leonard Gaydos; without their support and timely suggestions this project would not have been possible.

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INTRODUCTION

Landsats -1, 2, and now 3 have provided earth resource scientists the opportunity to acquire digital multispectral data repetitively over large regions of the earth's surface. These data are being used to map resources over extensive regions, to inventory specific resource parameters and to monitor change.

Application of these data to resource management problems has necessitated the development of interpretive methodologies that allow quick, consistent and accurate extraction of pertinent information. Evaluations of digital image analysis of Landsat multispectral scanner (MSS) data for mapping and inventorying natural resources have been made (Rohde, 1978). The temporal and spatial distribution of forest cover types is of prime concern in the management of our natural resources. Land cover information has commonly been obtained through ground sampling and mapping from high and low altitude aerial photography. These methods have typically been time-consuming and expensive. Through the use of satellite digital multispectral data, inventories have become less expensive per unit area, and can cover larger areas more rapidly than was previously possible. These studies and others have led to the development of image analysis techniques that are useful in resource inventory and mapping programs (Rohde 1978, Heller, 1975).

The U. S. Fish and Wildlife Service is concerned with anadromous fish populations of the Hoopa Valley Indian Reservation and Klamath River drainage. These populations have declined dramatically in recent years. Many factors have contributed to this decline, with logging and reduced stream flow suspected of playing major roles.

Anadromous fisheries management problems in this drainage are related to habitat and water conditions associated with the Klamath River, Trinity River and tributaries. Turbidity and water temperature are significant factors which influence the quality of fish habitat and increased siltation of stream gravels hinders successful spawning. Land conditions of slopes adjacent to these streams have a direct relationship to water quality and stream bottom condition. Land condition is regularly altered by timber harvest operations which remove forest vegetation and leave the land in early successional/regeneration stages for several years.

The Service, in cooperation with the National Aeronautics and Space Administration (NASA) and the Humboldt State University Remote Sensing Technology Transfer Project, used Landsat MSS data to inventory watershed conditions within the Hoopa Valley Indian Reservation in northern California. The objective of this study was to produce a Landsat vegetation cover map showing the locations of various land conditions with emphasis on barren or other highly erodable land.

The results of this study will assist the U. S. Fish and Wildlife Service in assessing the condition of the watershed on the reservation. Study results should also assist the Hoopa Valley Tribe and Bureau of Indian Affairs (BIA) in developing logging management programs beneficial to the fishery resource.

STUDY AREA

The Klamath River watershed is a heavily forested area containing large stands of virgin timber, and draining approximately 15,600 square miles (25,100 km^2) in Oregon and California. The majority of the drainage in California lies within the boundaries of the Six Rivers, Klamath, Shasta and Trinity National Forests. The lower 42 miles (67 km) of the Klamath River and lower 16 miles (26 km) of the Trinity River lie within the confines of the Hoopa Valley Indian Reservation.

The Klamath River flows westward from Iron Gate Dam, joins with the Shasta and Scott Rivers and then turns southward and unites with the Salmon River. After joining with the Trinity River, its largest tributary at Weitchpec, the Klamath River changes course and flows in a northwestward direction before emptying into the Pacific Ocean near Requa, California.

Throughout most of its course the Klamath River and its major tributaries, the Trinity, Shasta, Scott and Salmon rivers flow in steep V-cut valleys, between steep mountainous ridges. This feature, along with numerous riffles and "nickpoints" (small waterfalls), is indicative of rapid downcutting of the rivers through the underlying rock units.

In the study area, major rock units from east to west are the Galice, South Fork Mountain Schist and the Franciscan. (Bulletin 190 - California Division of Mines and Geology, 1964) The units are complexly faulted and fractured and due to this feature, contribute large amounts of clay rich sediment to the river system.

The Trinity River drains 2,970 square miles (4,778 km^2) while the Shasta, Scott, and Salmon Rivers each have drainage areas comprising approximately 800 square miles (1,287 km). Precipitation averages 40 inches (101 cm) annually throughout much of the basin and can exceed 90 inches (229 cm) per year along the coast. Precipitation gradually decreases inland to approximately six inches (15.2 cm) annually in the eastern portion of the basin.

The Hoopa Valley Indian Reservation comprises approximately 144,000 acres (58,299 ha) in Humboldt and Del Norte Counties, California. That portion of the reservation referred to as "The Square" (Fig.1) comprises 90,000 acres (36,437 ha) and is generally mountainous and rugged, ranging in elevation from 320 feet (97.5 m) to over 5,000 feet (1,524 m). Steep mountainous terrain comprises approximately 97 percent of "The Square" while the remaining area, the Hoopa Valley, is a low alluvial plain, which borders the Trinity River.

Climatic conditions in this area vary appreciably with rainfall averaging approximately 49 inches (124 cm) per year in the higher mountains near Weitchpec. Snowfall is negligible adjacent to the Trinity River but is substantial at higher elevations. Temperatures vary from mean January and July values of 54 F (12.2 C) and 70 F (21.1 C), respectively, with extreme variations to 16 F (-8.8 C) and 102 F (38.9 C). Soils fall within the broad vegetational class referred to as the Douglas Fir-White Oak prairie type. The timber covered terrain provides desirable habitat for blacktail deer, bear, quail, grouse and many fur bearing animals. The economic base of "The Square" is centered around the timber industry with large stands of Douglas fir providing the principal resource.

The two tribes which reside on the Hoopa Valley Indian Reservation include the Hupa Indians of "The Square" and the Yurok Indians who occupy land along the lower 42-mile (67.5 km) stretch of the Klamath River, frequently referred to as "The Strip". The original Hoopa Valley Reservation (that portion referred to as "The Square") created in 1864, was enlarged in 1891 to include a tract of land one mile in width on either side of the Klamath River extending from "The Square" to the Pacific Ocean. This extension incorporated the old Klamath River Reservation or "Lower 20" section created in 1855, into the Hoopa Valley Indian Reservation. Most of the "Lower 20" has since passed into non-Indian ownership, resulting in controversies concerning Indian ownership and rights within the Klamath River section of the reservation. Despite the large private holdings, the U.S. Supreme Court in 1973 held that the "Lower 20" portion was still considered "Indian Country".

Land-conditions and environmental factors along "The Strip" are similar to the Hoopa Square. The Klamath River is characterized by steep canyon walls with slopes in excess of 100 percent. Vegetational communities are similar to "The Square" with the exception of Redwoods which are found near the mouth of the Klamath River. Both "The Strip" and "The Square" contain many tributary streams which provide considerable anadromous fish habitat.

Tribal members of "The Square" have formed a government based on an official tribal roll, which has exercised a broad range of jurisdiction over Indian affairs, including fishing. A gill netting ordinance adopted by the tribe in 1976 prohibits the placement of any gill net which extends beyond two-thirds of the distance across the Trinity River, the placement of any net in front of the mouth of any tributary stream and the taking of fish for commercial purposes. Gill nets must also be lifted and removed from the river on a daily basis.

Unlike the Hupas, the Yurok people have had no officially-recognized tribal government, tribal roll or means of jurisdiction. Their lack of authority to control or regulate individual tribal fishermen has resulted in the current controversy surrounding Indian fishing rights on the Klamath River. An Ad Hoc Fishing Committee, comprised of Yurok Indians was formed in 1975 to advise the Yurok people concerning fishing rights. This committee disbanded in 1977 because of widespread tribal non-support. Attempts are underway by a number of Yurok leaders to form an interim tribal government on the reservation.

Fishery Resource

The Klamath River basin has historically supported large runs of salmon and steelhead trout, which have contributed considerably to sport and commercial fisheries in California and have provided the mainstay of Indian economy in the area. Heavily utilized trade routes from the interior to the sea, resulted in a lively commerce in dried fish and shells. Much of the ritual and labor of the Indian people was related to the capture and care of salmon and steelhead. The fall chinook salmon run was most important because low river flows and considerable numbers of large fish provided optimum fishing conditions. The flesh of this fish was ideal for smoke curing and storing for winter use. Indians historically constructed fish weirs of logs, poles and brush across the rivers and speared or netted upstream migrants. Weirs remained in place until late fall high flows washed them away. In recent decades, weirs have been replaced by more efficient gill nets which have raised a variety of jurisdictional questions regarding Indian fishing rights.

Biologists with the U.S. Forest Service estimated an annual net economic value of salmon and steelhead fisheries attributable to the Klamath River watershed, exclusive of the Trinity River drainage, of $21.5 million. This value includes sport and commercial fisheries but does not take into account the Indian subsistence fisheries. Average annual values per mile of chinook salmon, coho salmon and steelhead trout habitat within the Klamath National Forest were also estimated at $25,000, $2,300 and $4,500 respectively (Kesner, 1977).

Eight anadromous fishes spend portions of their life cycles in the Klamath River System: chinook or king salmon (Oncorhynchus tshawytscha), coho or silver salmon (Oncorhynchus kisutch), steelhead trout (Salmo gairdneri), coastal cutthroat trout (Salmo clarki clarki), brown trout (Salmo trutta), green sturgeon (Acipenser medirostris), American shad (Alosa sapidissima), and Pacific lamprey (Lampetra tridentata). Small runs of white sturgeon (Acipenser transmontanus) may also occur in the basin (Moyle, 1976). Resident species include native rainbow trout (Salmo gairdneri), brown trout (Salmo trutta), eastern brook trout (Salveninus fontinalis), and several species of non-game and warm water game fishes. Notable marine visitors include the starry flounder (Platichthys stellatus), surf smelt (Hypomesus pretiosus), and redtail surfperch (Amphistichus rhodoterus)(Rankel, 1978). A review of life history information for respective species along with a summary of temporal run-size trends appears in Rankel (1978).

MATERIALS AND METHODS

Landsat Overview

The Earth Resource Technology Satellite Program (Landsat 1, 2 and 3) has been designated as a research tool to demonstrate the feasibility of remote sensing from space as a practical approach to management of earth's resources. The data-gathering satellites operate in sun-synchonous, near-circular orbit, at an altitude of 917 km (570 miles). The Landsat satellites sense (reflected solar energy) with a multispectral scanner (MSS) in four spectral bands from 0.5 to 1.1 micrometers (μm). The scanner records a swath 100 nautical miles wide in a continuous strip. Each strip or scene is 2340 scan lines long and 3240 scan lines wide. These scenes are divided into four strips; each strip is 810 pixels wide. Individual pixels (ground resolution elements) measure 78 meters along the direction of the orbit's path and 57 meters in width. The size of each pixel element is the greatest limiting factor on spatial resolution.

The Landsat data is directly recorded in a digital format on magnetic tape, greatly facilitating the application of computer processing programs. At the initial stage of the inventory of natural resources, the utilization of Landsat data to generate a set of statistics from the computer compatible tapes (CCT) appears useful for regional surveys of existing vegetation cover and for monitoring changes of the land cover types.

Image Selection, Registration and Preprocessing

After a review of the vegetation communities, desired land condition classes and ground truthing time frame, an April 12, 1977 Landsat scene was selected for analysis. A computer compatible tape was acquired from Earth Resources Observation Systems (EROS) Data Center. Radiometric anomalies, including bad data lines and points, radiometric striping and atmospheric scattering were not corrected or normalized before processing. These errors were not significant for the data tape.

To correct the inherent geometric errors in the Landsat digital data, systematic and predictable errors were modeled and corrections were applied. Non-systematic errors were also corrected in order to account for variations in spacecraft attitude and altitude. In natural resource inventories it is important to have accurate locations of sample plots or specific resource features.

Once preprocessing had been completed, a window was selected from the Landsat scene. The window selected to cover this area was approximately 1,000 pixels (acres) on a side, 1,000,000 bytes of information in each of the four channels.

Digital Image Processing

The Landsat digital data was analyzed using interactive procedures and multispectral classification algorithms based on multivariate discriminant analysis theory (Morrison, 1967). The purpose of digital image processing is to group pixels spectrally into a number of meaningful categories that can be correlated to natural resource features. This grouping is done through a Euclidean minimum distance or a Gaussian maximum likelihood decision rule (Morrison, 1967). The Earth Resource Technology Satellite Data Interpreter and TENEX Operation Recorder (EDITOR) software was used exclusively to carry out these functions.

EDITOR is a three-fold system for interactive image processing, file management, and ILLIAC IV high speed central computer interfacing. Interactive image processing allows for the manipulation and display of Landsat digital data by the analyst at a local level using a portable computer terminal. The File Management system controls input and output of data and editing of file structure. ILLIAC IV is used for batch runs of submitted data from files of the two preceding parts of the system. EDITOR is arranged under a multi-level command system, allowing access to lower levels only through the preceding level. There are six primary functions which can use either raw or categorized data in the analysis process. The system provides the user great flexibility in processing digital Landsat data.

Unsupervised Classification

The first step taken in processing the Landsat scene was an ILLIAC IV unsupervised classification. An arbitrary number of spectral classes (20) was chosen and submitted to the ILLIAC IV for unsupervised classification. The computer assigned alphanumeric symbols to the spectral classes that it selected using Euclidean minimum distance, and a line printer map was produced. The line printer map, at approximately 1:24,000 scale, was useful in determining the geographical location of spectral classes A two-channel map was developed using channels 2 (red), and 4 (infrared). The spectral means of each class were plotted in their respective channels. At this point it was possible to begin making inferences as to which resource types the classes represented. U-2 and low level aerial photography were used to assign reliable resource labels to the computer assigned classes.

Calibration File

In order to assure accurate location of resource features on the Landsat scene, a calibration file was produced. Unique pixels or control points on the line printer map and their corresponding location on 7½ minute quadrangle maps were recorded and analyzed using least squares regression techniques. Row/column and latitude/longitude of the control points were entered into the computer and were edited. Control point editing is the process by which mis-located points are eliminated to achieve accuracy of within one pixel (80 m) of the true location. The calibration file standardized the Landsat scene to United States Geological Survey (USGS) quadrangle maps. This insures accurate location of resource features as well as training areas.

Supervised Classification - Guided Clustering

Supervised classification with guided clustering uses independent information to define statistics that establish classification categories. Areas were selected that were spectrally homogeneous for each resource type. The process of guided clustering enables the analyst to account for spectral heterogeneity within a training field. A cover type may be homogeneous in terms of resource category definition, but may contain several spectral signatures.

Approximately 100 training fields were selected and recorded on USGS quadrangle maps and labeled according to resource category. The training fields were digitized, labeled and stored in the computer for post classification processing. Each quadrangle map became a digitization segment. The segments as well as the irregular polygon training fields within them, were stored in computer memory. Ground truth for each field was recorded and each segment was grouped or "packed" into files containing like ground truth information. Each pack-file was labeled as to resource type or category represented.

After the packing process each pack-file was analyzed for spectral homogeneity. Raw data from these files were displayed as histograms and inferences were made as to the number of spectral classes present. The histograms were valuable in determining the number of classes for each training field (Fig. 2).

Guided clustering was performed on each pack-file to determine the means and variances of the spectral cluster chosen. Swain Fu distances (Swain, 1968) between the mean of each cluster were then listed in a separability matrix. Decisions were made at this point as to additions or eliminations of clusters within the training fields. This was based on the separability of the clusters and the number of pixels within each cluster. The remaining clusters were then defined as statistics files which contained means, variances and co-variances for categories created by clustering. Each pack-file had then become a statistics file, which contained one to several spectral classes depending on the results of the guided clustering.

Spectral confusion was found to exist between various statistics files. This confusion was anticipated, as each training field was clustered independently. The EDITOR routine called "pool and merge" was used to combine statistics files and the spectral classes within them. It also allowed for the deleting of individual classes which eliminated spectral confusion between like classes. For example, two statistics files were re-called and merged together to create one file. A separability matrix was produced and classes were either pooled together due to like features, deleted because of spectral conflict with other classes, or written as is, if spectral separability was retained. This iterative process continued until all of the statistics files were merged and pooled together. As a result, a final supervised/guided clustering statistics file was produced.

A classification was produced with the original segments using the final statistics and printed out with the appropriate alphanumeric symbols that depicted the individual classes (Fig. 3). Using the previous ground truth information, known resource labels were assigned to the final classes. U-2 photo interpretation was then directed toward identifying those individual classes which could not be identified from the previous ground truth information.

After assigning resource names, the previously described unsupervised classification was used as an input statistics file and merged with the supervised statistics file. This was done in order to identify new spectral categories that were not included in the training statistics. This form of double classification proved to be helpful in identifying the remainder of the unique spectral classes present in the study area.

Classification

A "Gaussian maximum likelihood classification" was completed of the Landsat scene. The final statistics file from the supervised-unsupervised classification was submitted to the ILLIAC IV for classifying. A line printer output and an Interactive Digital Image Manipulation System (IDIMS) tape was produced. On IDIMS, it was possible to interactively color the classes. The Landsat scene was displayed on the

Cathode Ray Tube (CRT) and color selection was completed. From this, 35 mm slides were taken and used as preliminary products. A Dicomed, a color photographic print, was also produced and was helpful in choosing the final color scheme.

Stratification

The political boundaries of the Hoopa Valley Indian Reservation were stratified into the Landsat scene (Fig. 4). Pixels occurring on the boundaries were removed by the computer and replaced with dummy pixels, which were colored white. The Hoopa Square was divided into management units which were stratified into the Landsat scene (Fig. 5). The management units were developed through personal communication with B.I.A., the Forestry Department (Soto personal communication, 1978). They tend to correspond with the existing cutting block compartments.

Field Data Collection Techniques

Field data or ground truth was collected for each land condition category. The study area was divided into sub-sections in order to expedite the field data collection process. These sub-sections had been previously delineated by the B.I.A. at Hoopa and were outlined in comprehensive logging maps. These were then used to direct the collection of ground truth data.

Aerial photographs of the area were examined to determine the types of land condition categories present. These categories were then aggregated together and a representative sample was chosen for field inspection.

Each field plot visited was inspected for plant species

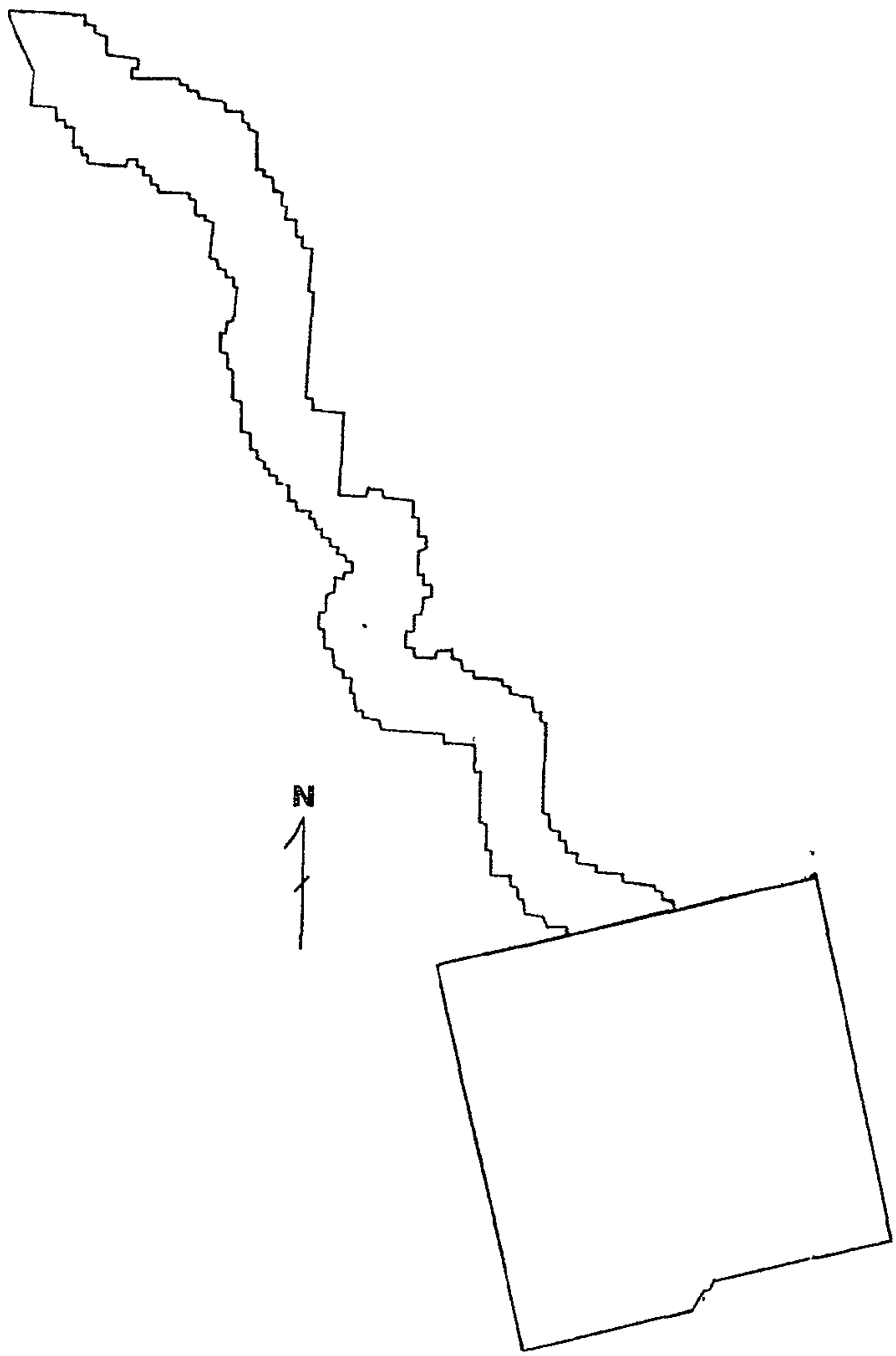

Figure 4. Plotter representation of the Klamath Extension and Hoopa Square.

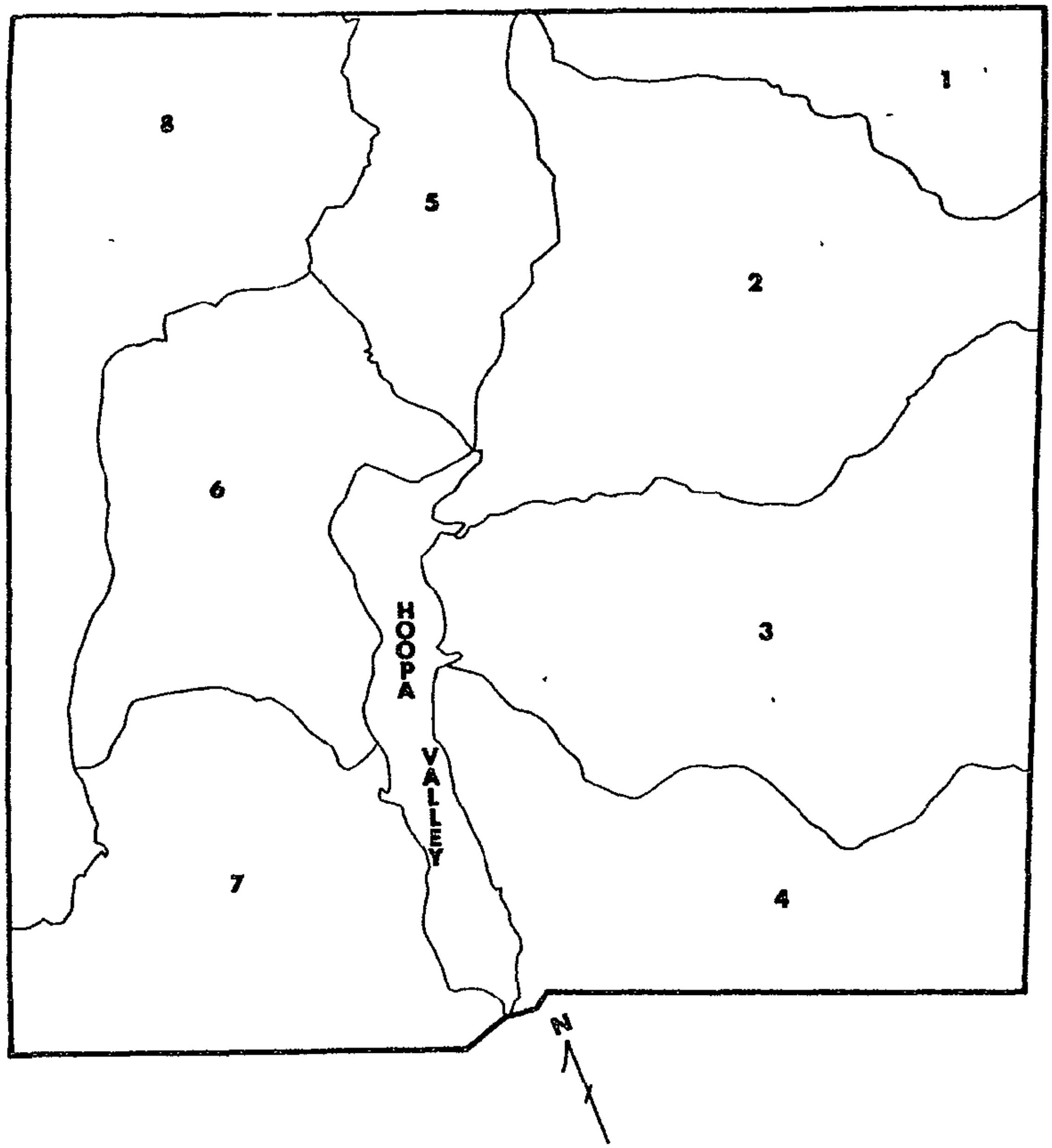

Figure 5. Plotter represention of the eight management units, Hoopa Square.

composition, soil condition, erosion potential, aspect and slope. Furthermore, each field plot was visually inspected and an occular estimation of the percent crown closure was made.

These field plots became training fields for the classification and were used to standardize the airphoto interpretation when used for further ground truth collecting. Approximately 80% of the ground truth information was collected from airphotos. This provided for quick and consistent data collection that could be easily verified or duplicated.

Evaluation

The Landsat classified scene (April, 1977) was evaluated using U-2 color infrared photography (May, 1978). A nine by eighteen inch format transparency (1:32,500) of the Hoopa Valley and adjoining forest land was enlarged and printed to match the 1:24,000 scale of the line printer map.

The evaluation site was selected to be representative of the study area and contained all of the major cover categories defined in the classification. The site was also adjacent to a unique meander in the Trinity River which facilitated accurate pixel location.

A black line grid was produced on clear mylar to allow an accurate fit to the line printer map. Each grid square represented the size of a pixel at the scale of the line printer map. The grid was placed on the classification and prominent geographical features (e.g., the Trinity River) were identified and labeled. The grid was then placed on the photograph and rotated until a local fit was established, matching geographical features. Pin marks were placed on both products to assure registration.

The mylar grid was divided into a series of nine by nine inch pixel sampling clusters, eliminating those which had pixels occurring outside of the photograph. Clusters were selected at random and sampled without replacement. The mylar grid was locally fit to the photograph to allow for relief displacement errors. Photo-interpretation was used to evaluate each pixel as to its true land cover category and if the Landsat classification was correct. A pixel count per class sampled was also recorded to insure adequate sample size. Errors of omission and commission were calculated and point estimations of the mean probability of correct classification were determined.

Errors of omission were determined by using binomial approximation sampling theory (Cochran, 1977). The variance of each Landsat class was calculated using a weighted sum of squares of deviations of the p_λ (probability of correct classification in class$_\lambda$) from the population value P.

$$P = \frac{\Sigma a_\lambda}{\Sigma m_\lambda}$$

$$V(P) = \frac{\Sigma a_\lambda{}^2 - 2p\,\Sigma a_\lambda m_\lambda + P^2\,\Sigma m_\lambda{}^2}{N\bar{m}^2 \quad N-1}$$

Where $\bar{m} = \Sigma m_\lambda/n$ is the average number of elements per cluster in the sample.

From this, standard deviation and a lower limit at 95 percent confidence were calculated for each class.

Classification Aggregation

The classification was aggregated as to Landsat class using the NASA IBM 360 computer. The "Hoopa Square" was aggregated separately from the "Klamath Strip". "The Square" was also divided into the management units and summary statistics were produced. The aggregation statistics were accessed through the EDITOR software. Summaries of the number of acres, hectares, and pixels occuring within each class were calculated per area.

RESULTS AND DISCUSSION

Category Description

The Landsat scene was classified into twenty-four spectral classes (Table 1). From the computer training process seven major land condition categories could be identified by thirteen distinct spectral classes. In addition, three vegetation categories were found which comprised eight spectral classes. Two other resource categories, water and snow were identified and consisted of three spectral classes. Land condition categories as well as vegetation categories were developed throughout the classification process. Computer training was completed on a variety of land condition and vegetation sites. The computer was used to determine the final categories through algorithm clustering.

Land condition categories were identified by percent crown closure. Crown closure was defined as the proportion of ground covered by perennial plants. Land condition category >80%, consisting of class A, was characterized by dense brush and a minimum of exposed bare soil (Fig.6). Vegetation cover consisted primarily of Ceanothus, and was greater than 15 feet in height. At times, scattered hardwoods could also be found within this category. Erosion was found not to be significant as the percent crown closure was high. Categories 60% and 50% were similar in appearance except for a greater amount of bare soil in the 50% category. Spectrally, the 60% category could be identified by spectral classes F, B, and O, resulting in more class discrimination than the 50% category which consisted of spectral class nine. Category 40% was very unique spectrally and could be identified by four spectral classes, 4, D, E and G. Vegetation in these areas consisted of low

Table 1. Land Condition - Resource Categories and the Number of Spectral Classes.

Condition Category	Number of Spectral Classes
Conifer	2
Mixed	5
Hardwoods	1
>80% CC[a] Brush	1
60% CC "	3
50% CC "	1
40% CC "	4
30% CC "	1
20% CC "	2
<10% CC "	1
Water	1
Snow	2
Total	24

[a]CC = Crown Closure

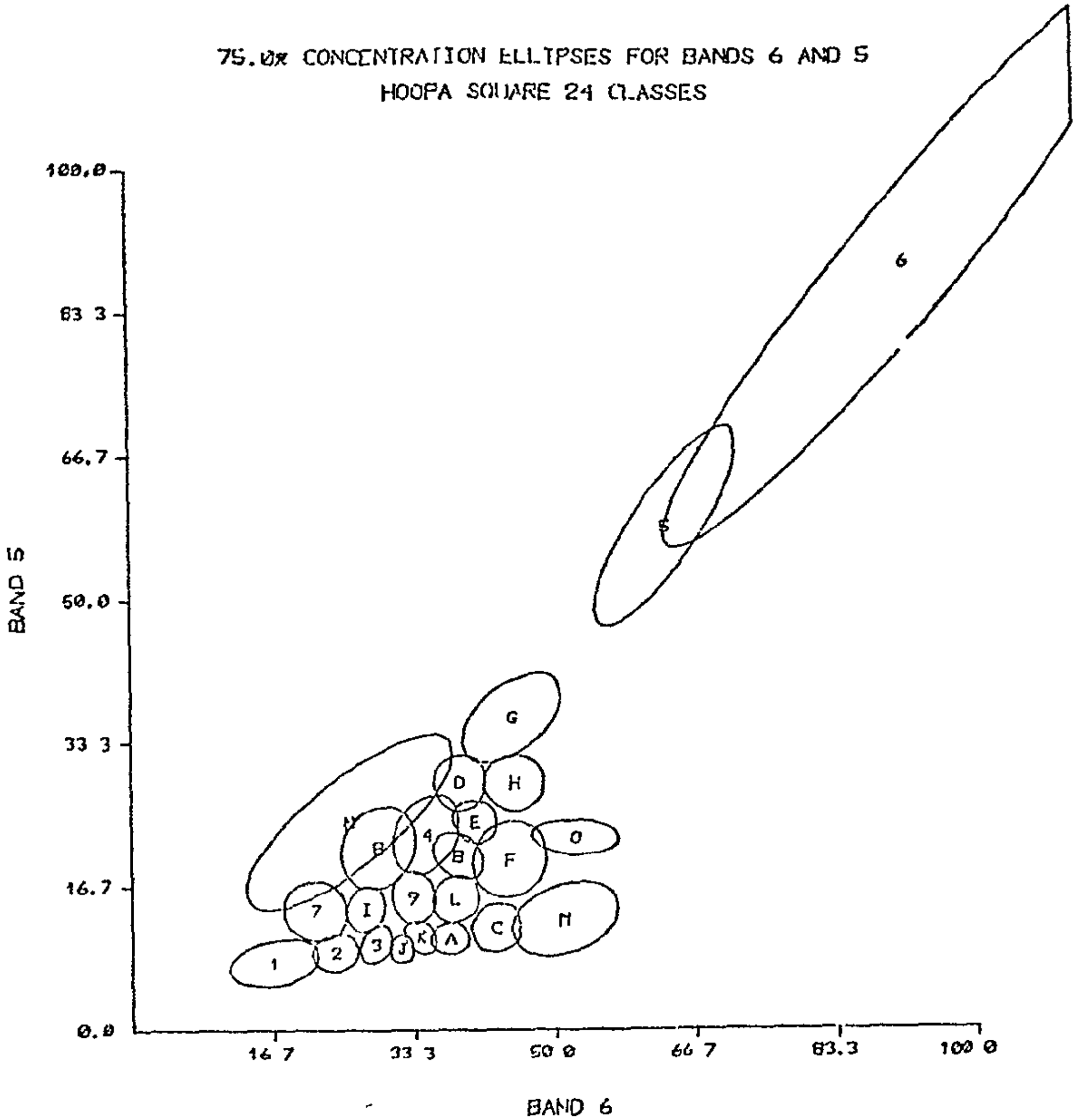

Figure 6. Plotter graph of the final 24 spectral classes in two bands, Band 5 (Red .6 - .7), Band 6 (IR .7 - .8).

brush and scattered small perennials. Annuals, e.g., grasses, were insignificant.

Erosion in these areas seemed to be low. However, each site has the potential for extreme mass wastage, as erosion is site specific in this region. It was found that erosion increased as the percent crown closure decreased. The 30% category was a prime example of this as evidence of surface erosion was present. This category was represented by spectral class H and comprised a relatively small portion of the classification.

Categories 20% and <10% exhibited the highest potential for erosion. The 20% crown closure category was relatively unstable even though covered partially by vegetation. This is substantiated by the presence of two spectral classes 7 and 8 indicating residual plant life. The bare soil category, <10% crown closure spectral class I, was very unstable with little or no ground cover. This condition was usually a result of recent logging or land slides. Through field examinations it was determined that the majority of the land condition classes were caused directly or indirectly by logging practices.

Vegetational communities were aggregated into three categories. Conifer was identified by spectral classes 1 and 2 which was correlated to tree density. Douglas Fir (Pseudotsuga menziesii) was the primary conifer and extensive stands do exist throughout the Reservation. The mixed category was a combination of conifer, hardwood and brush. These vegetation types, and mixes, were aggregated together. As a result five spectral classes (3, C, J, K and L) were identified as mixed. Hardwoods, a spectrally distinct category, were represented by spectral class M and could be found mixed throughout the forest cover. Hardwoods were also noted in pockets along valleys and ridges. Tanoak (Lithocarpus densiflorus), madrone (Arbutus menziesii), black oak (Quercus kellogii), white oak (Quercus lobata) and bigleaf maple (Acer macrophyllum) were the exclusive species.

Final Products

Final products were developed by applying the final classification statistics to the raw Landsat data. Photographic reproductions were produced using designated colors to represent the final categories.

Figure 7 is a pictorial representation of the Hoopa Square and Klamath Extension. The white boundary lines are the political boundaries of the study area that were stratified into the scene. Ground truth and classification evaluations were completed only within those lines. Signature extension was used to classify the remaining area for which no field work had been completed, and consequently was not evaluated.

Conifer was color-coded dark green and can be seen throughout the study area (Fig. 8). The medium green areas represent the mixed category and the light green areas are hardwoods. These shades of green were used to identify areas of heavy forest cover. Water was color-coded aqua and can be seen within the Hoopa Valley and extending to the coast at Requa.

Land condition categories were colored various shades of red and brown in order to highlight the low crown closure areas as these areas are relatively unstable and require special management considerations. The red areas depict the <10% CC category which appears scattered throughout "The Strip" and "Square". The remaining shades of red correspond to other low crown closure categories. These are represented by

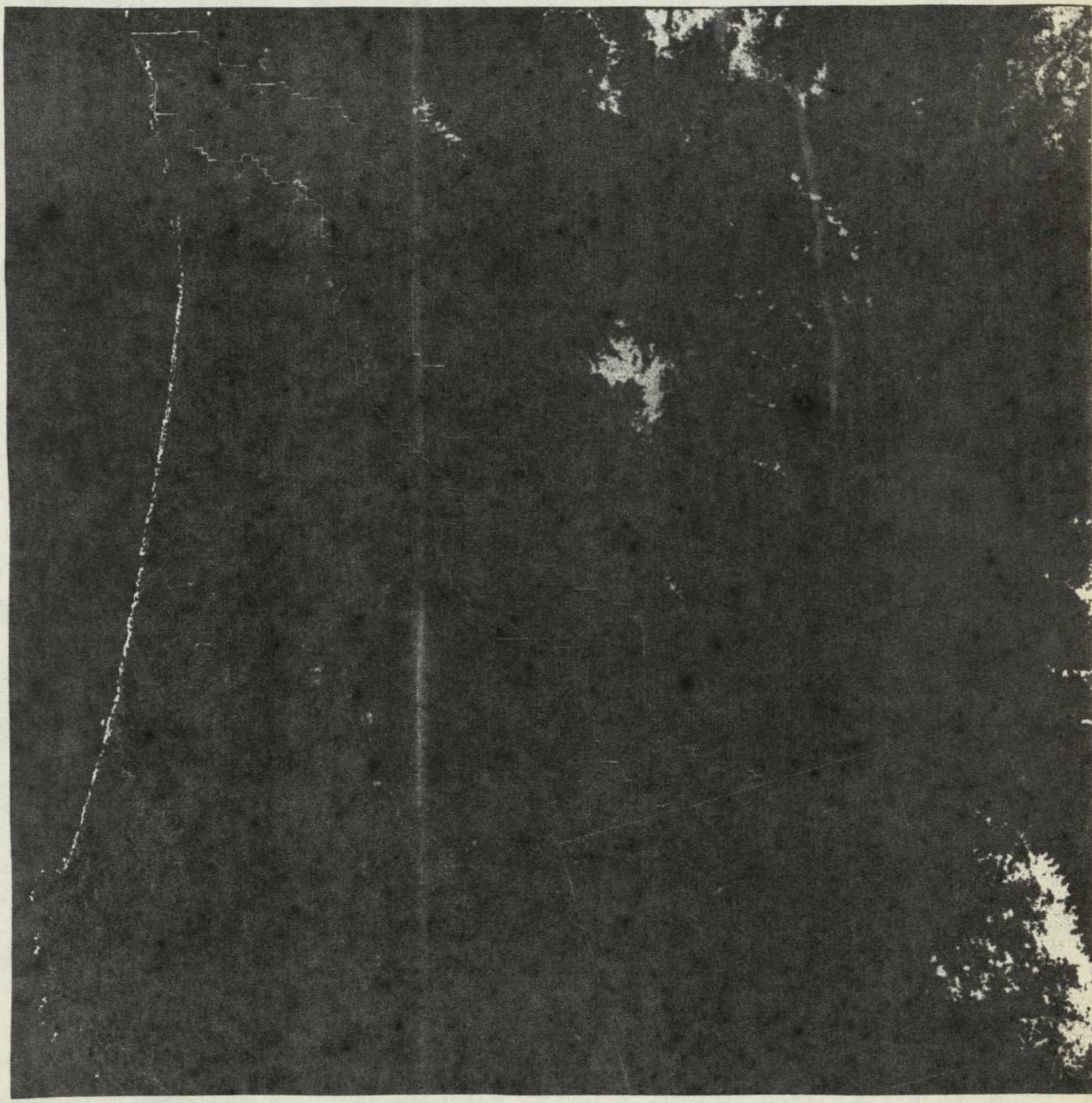

Figure 7. Hoopa Square and Klamath Extension - Final Product

CATEGORY	COLOR
CONIFER	DK. GREEN
MIXED	GREEN
HARDWOODS	LT. GREEN
>80% CC[a]	BROWN
60% CC	TAN
50% CC	PEACH
40% CC	YELLOW
30% CC	PINK
20% CC	LT. RED
<10% CC	RED
WATER	AQUA
SNOW	WHITE
HOOPA VALLEY	GREY

[a]CC = Crown Closure

Figure 8. Color Key for Final Products.

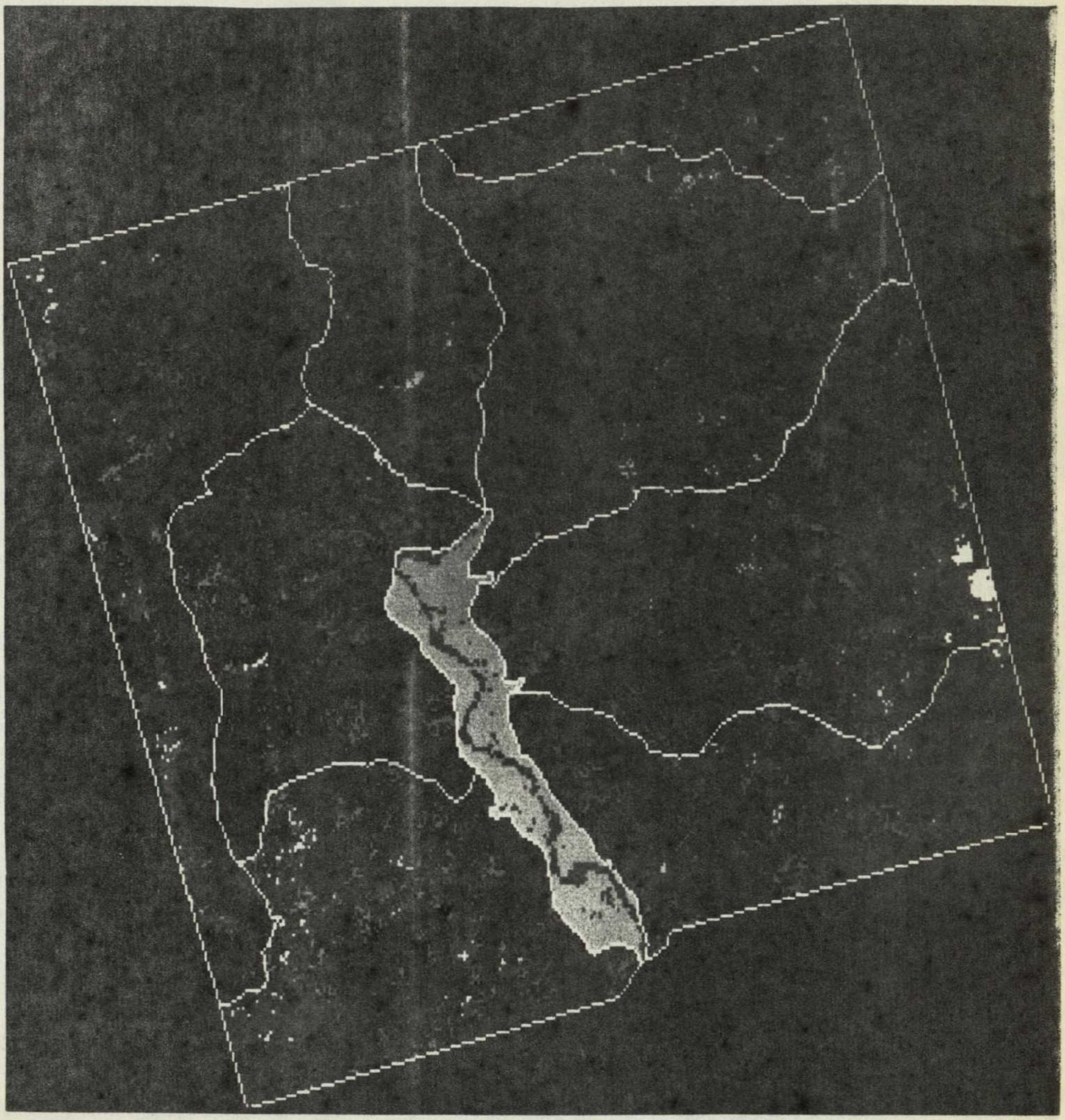

Figure 9. Hoopa Square with Management Units - Final Product.

Table 2. Area Estimation of Landsat Categories per Management unit, Hoopa Square, Klamath Extension.

Units		Hoopa Square 1	2	3	4	5	6	7	8	Total	Klamath Extension
Conifer	P[a]	1646	2780	4227	2171	302	1100	1659	2910	16795	6080
	A[b]	1844	3114	4734	2432	338	1232	1858	3259	18811	6810
	H[c]	746	1260	1916	984	137	499	752	1319	7613	2756
Mixed		1188	5144	4639	3194	2752	4501	3231	4301	28950	16577
		1331	5761	5196	3577	3082	5041	3619	4817	32424	18566
		538	2332	2103	1448	1247	2040	1464	1949	13121	7514
Hardwoods		135	555	189	111	113	132	175	260	1670	1230
		151	622	212	124	127	148	196	291	1871	1378
		61	252	86	50	51	60	79	118	757	558
>80% CC[d] Brush		245	1712	898	1073	719	932	780	867	7226	3051
		274	1917	1006	1202	805	1044	874	971	8093	3417
		111	776	407	486	326	422	354	393	3294	1383
60% CC Brush		227	713	326	313	292	483	835	505	3694	4174
		254	799	365	351	327	541	935	566	4138	4675
		103	323	148	142	132	219	378	229	1674	1892
50% CC Brush		159	518	783	450	382	649	690	487	4118	4294
		178	580	877	504	428	727	773	545	4612	4809
		72	235	355	204	173	294	313	221	1867	1946
40% CC Brush		161	652	535	290	296	226	723	588	3471	2511
		180	730	599	325	332	253	810	659	3888	2812
		73	296	242	131	134	102	328	267	1573	1138

Table 2. Area Estimation of Landsat Categories per Management unit, Hoopa Square, Klamath Extension (Continued).

Units	Hoopa Square 1	2	3	4	5	6	7	8	Total	Klamath Extension	
30% CC Brush	45	100	58	27	41	5	92	59	427	497	P[a]
	50	112	65	30	46	6	103	66	478	557	A[b]
	20	45	26	12	19	2	42	27	193	225	H[c]
20% CC Brush	422	690	1029	613	106	199	557	817	4433	4031	
	473	773	1152	687	119	223	624	915	4966	4515	
	191	313	466	278	48	90	252	370	2008	1827	
<10% CC Brush	210	482	998	547	141	471	516	523	3888	3657	
	235	540	1118	613	158	528	578	586	4356	4096	
	95	218	452	248	64	213	234	237	1761	1658	
Water	10	47	32	24	28	5	16	10	172	3412	
	11	53	36	27	31	6	18	11	193	3821	
	5	21	15	11	13	2	7	5	49	1547	
Snow	0	2	114	5	0	7	1	0	129	30	
	0	2	128	6	0	8	1	0	145	34	
	0	1	52	2	0	3	0	0	58	14	
Total	4448	13395	13828	8818	5172	8710	9275	11327	74973	49544	
	4981	15003	15488	9878	5793	9757	10389	12686	83975	55490	
	2015	6072	6268	3996	2344	3946	4203	5135	33979	22458	

[a]P = Pixels [c]H = Hectars

[b]A = Acres [d]CC = Crown Closure

Table 3. Percent Area Estimation of Landsat Categories per Management Unit, Hoopa Square and Klamath Extension.

Units		Hoopa Square								Klamath Extension
	1	2	3	4	5	6	7	8	Total	
Conifer	37.0	21.0	31.0	25.1	6.0	13.0	18.0	26.1	22.0	12.3
Mixed	27.0	38.0	34.0	36.2	53.0	51.0	35.0	38.0	39.1	33.4
Hardwoods	3.0	4.0	1.5	1.0	2.0	1.5	2.0	2.0	2.0	2.3
>80% CC[a] Brush	5.5	13.0	6.4	12.0	14.0	11.0	8.0	8.1	10.0	6.2
60% CC Brush	5.0	5.0	2.2	4.0	6.0	5.5	9.0	4.0	5.1	8.1
50% CC Brush	3.5	4.0	6.0	5.0	7.0	7.5	7.0	4.0	5.0	9.2
40% CC Brush	3.6	5.0	4.0	3.0	6.0	3.0	8.0	5.2	5.0	5.0
30% CC Brush	1.0	0.7	0.4	0.3	0.5	0.1	0.9	0.5	0.5	1.0
20% CC Brush	9.5	5.0	7.2	7.1	2.0	2.0	6.0	7.0	6.1	8.2
<10% CC Brush	4.7	4.0	7.0	6.0	3.0	5.2	6.0	5.0	5.0	7.0
Water	0.2	0.2	0.2	0.2	0.5	0.1	0.1	0.1	0.2	7.1
Snow	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.1
Total	100	100	100	100	100	100	100	100	100	100

[a]CC = Crown Closure

substantial (approximately 11 percent) portion of "The Square". It can be stated at this point that large areas of barren or nearly barren soil exist on the Reservation.

Within "The Strip", the mixed category was also the largest class, accounting for approximately 33 percent of the area or 18,566 acres (7.514 ha). Conifer comprised 12.3 percent of the area, while <10% CC comprised 7 percent. The 50% CC category was the largest land condition category covering over 9% percent of "The Strip". The low crown closure categories (<10%, 20% and 30% CC) comprised over 16 percent of the total area, which appears to be a result of logging.

Evaluation

The overall mean probability of correct classification for omission was 91.8 percent (Table 4). This can be used as an indicator of classification reliability. Accuracy percentages for omission indicate the probability that a pixel, truly representing class "λ" on the ground, will be classified into class "λ". Category accuracy varied from 97.3 percent for conifer to 81.0 percent for 30% crown closure. The relatively low accuracy of the 30% CC category was a result of sample size, as very few representatives of this category were found in the evaluation site. The 20% and <10% crown closure categories exhibited accuracies of 95.6 and 93.3 percent respectively. This accuracy is much higher than the level found in previous studies. Aldrich (1975) stated that through the use of computer training and mapping from the Pacific Southwest (PSW) at Berkeley and the Laboratory for Applications of Remote Sensing (LARS) at Purdue University, bare soil could be identified with an accuracy ranging from 7 to 57 percent. Through our use of

Table 4. Error of Omission

Category	Mean Probability of Correct Classification	Standard Deviation	Cluster Sample Size (# of clusters)	Lower Limit 95% Confidence Level
Conifer	0.973	0.012	15	-0.021 (0.95)
Mixed	0.883	0.022	18	-0.038 (0.85)
Hardwoods	0.880	0.038	14	-0.076 (0.81)
>80% CC[a] Brush	0.910	0.040	15	-0.070 (0.84)
60% CC "	0.850	0.055	17	-0.096 (0.75)
50% CC "	0.951	0.032	23	-0.055 (0.90)
40% CC "	0.971	0.025	9	-0.046 (0.93)
30% CC "	0.810	0.146	7	-0.276 (0.54)
20% CC "	0.956	0.027	17	-0.047 (0.91)
<10% CC "	0.933	0.024	18	-0.041 (0.89)
Water	0.863	0.08	6	-0.165 (0.70)
Overall	0.916	0.0089	36	-0.015 (0.90)

[a]CC = Crown Closure

guided clustering and the pooling of supervised and unsupervised statistics, a higher accuracy was attained. Furthermore, the Reservation study area was considerably smaller, allowing for more intensive field work.

Commission errors were also calculated and the overall mean probability of correct classification was 91.4 percent (Table 5). These percentages indicate the probability that a pixel, classified into class "λ", truly represents class "λ" on the ground.

Accuracy ranged from 97.6 percent for the conifer category to 67.0 percent for the >80% CC category. The low accuracy for the >80% category was a result of two factors. First, mis-classification occurred because of dead trees in the stand. A true mixed category on the ground was being classified as >80% crown closure. This was due to the spectral confusion between bare soil and dead trees. In addition, misclassification occurred with black oak. At the time of year of the Landsat scene black oak had not 'leafed out'. This factor resulted in holes in the canopy which influenced the spectral response. We feel that these problems could have been resolved with more computer training on the problem areas.

Table 5. Error of Commission

Category	Mean Probability of Correct Classification	Cluster Sample Size (# of clusters)
Conifer	0.976	15
Mixed	0.974	18
Hardwoods	0.914	7
>80% CC[a] Brush	0.670	15
60% CC "	0.884	8
50% CC "	0.858	20
40% CC "	0.971	9
30% CC "	0.884	8
20% CC "	0.913	11
<10% CC "	0.804	11
Water	0.833	4
Overall	0.914	30

[a]CC = Crown Closure

SUMMARY AND CONCLUSIONS

Landsat digital data, with supporting U-2 aerial photographs and ground truth sampling, was used to map forest land condition and vegetation cover on the Hoopa Valley Indian Reservation. The Landsat digital data was analyzed using the EDITOR software package, which was accessed through a portable computer terminal at Humboldt State University. EDITOR consists of a series of interactive procedures and multispectral classification algorithms based on Multivariate Discriminate Analysis.

Guided clustering was used to develop training statistics and to evaluate initial classification results. Final statistics were generated and used to classify the Landsat scene. The classification provided an inventory of the area within the land condition categories defined. A pseudo-color map was produced and tabular summaries were developed for each category, by forest management unit. The classification accuracy was evaluated by using a pixel grid on U-2 photography. Classification errors of omission and commission were calculated using a binomial approximation within a cluster sampling design.

The following major conclusions were reached:

1) Landsat MSS data can be processed, using guided clustering techniques,to accurately map (81% to 97% accuracy) land condition and vegetation cover categories (e.g., conifer, mixed and hardwoods) and percent crown closure of brush (seven categories from<10% to>80% CC) in regions of rugged, mountainous terrain.
2) A successful classification requires reliable and adequate ground information, an interactive computer system with

clustering capabilities and adequate time to allow for re-training to increase classification accuracy.

3) Guided clustering techniques are essential for developing training statistics containing the maximum number of spectral classes.

4) A successful classification can be accomplished using a remote computer terminal accessed by phone to a central computer.

5) The vegetation complex of the Hoopa Indian Reservation was described as follows:

Conifer Forest	18%
Mixed Forest	36%
Hardwood Forest.	2%
Brush - >80% Crown Closure . . .	8%
" - 60% " " . . .	6%
" - 50% " " . . .	7%
" - 40% " " . . .	5%
" - 30% " " . . .	1%
" - 20% " " . . .	7%
" - <10% " " . . .	6%
Water -	3%
Snow -	1%
TOTAL	100%

6) The crown closure land condition categories comprise approximately 40 percent of the Hoopa Indian Reservation. The sparse brush or crown closure categories (<10% to 30% CC) cover 14 percent and the heavy crown closure (40% to >80% CC) categories cover approximately 26 percent.

GLOSSARY

algorithm - A mathematical formula used to calculate a statistic used to place pixels in various categories.

anadromous fish - Several species of fish that live their life at sea and return to fresh water to reproduce.

atmospheric scattering - Light scattered by the atmosphere which causes a near-equal increase in brightness for all pixels, usually greater in Band 4.

bad data lines - Scan lines containing no data.

band - A wavelength interval in the electromagnetic spectrum. Landsat bands are numbered 4, 5, 6, 7. Often computer analysts number them as channels 1, 2, 3, 4.

bit - In digital computer terminology, this is a binary digit that is an exponent of the base of 2.

byte - A group of eight bits of digital data.

calibration file - A collection of points common to a map base and the Landsat image used to 'fit' the Landsat data to the map.

categorized data - Raw data that has been placed into a category.

channels - Wavelength intervals of light energy received by a remote sensing system. See band.

classes - Categories that spectral responses are placed into.

classification - The process of assigning individual pixels of a multispectral image to categories, generally on the basis of spectral-reflectance characteristics.

clustering - The process of mathematically assigning similar spectral signatures to classes or categories.

control points - Geographical locations that the Landsat image is corrected or aligned to.

C.R.T. - Cathode ray tube.

dicomed - A pseudo-color photographic reproduction of classified Landsat data.

digitization - The process of converting an image recorded originally on photographic material into a numerical format.

EDITOR software - An interactive computer program that analyses Landsat digital data using guided clustering procedures.

Euclidean minimum distance - A statistical decision rule used by the cluster analysis routine to assign pixels to various categories.

Gaussian maximum likelihood classifier - A statistical decision rule used in conjunction with known training sites to assign pixels to various categories.

ground truth - Data that is collected in the field, on-the-ground inspection.

IDIMS - Hardware developed by ESL Corporation that will classify and interactively color Landsat data.

ILLIAC IV - A parallel processing computer capable of very fast processing speeds. This system is not interactive.

interactive processing - The method of data processing in which the operator views preliminary results and can alter the instructions to the computer to achive optimum results.

infrared - The infrared region of the electromagnetic spectrum that includes wavelengths from 0.7 m to 1 mm.

Landsat - An unmanned earth-orbiting NASA satellite that transmits multispectral images in the 0.4 to 1.1 μm region to earth receiv-stations (formerly called ERTS).

line printer map - A digital computer printout. This can represent gray level, raw or categorized data.

MSS - multispectral scanner system of Landsat that acquires images at four wavelength bands in the visible and reflected IR regions.

management units - Arbitrarily selected subsections of the Hoopa Valley Indian Reservation that correspond with existing cut-block compartments. This facilitated summaries of acres and hectares per area.

non-systematic errors - Variations in spacecraft attitude, velocity and altitude.

packing - The process of taking spectrally similar data from geographically divergent training areas and merging them into one category.

picture element - In a digitized image this is the area on the ground represented by each digital value.

pixel - A contraction of picture element.

pool and merge - The process of putting spectral classes together or deleting to create a final statistic file.

radiometric striping - The striped effect in the image caused by an abnormal increase in the brightness of every sixth scan line.

raw data - Landsat spectral data that has not been classified or enhanced.

separability matrix - A table of separability statistics indicating the statistical separation of defined spectral categories in spectral space.

Signature - A characteristic, or combination of characteristics, by which a material or an object may be identified on an image or photograph.

space craft attitude - The angular orientation with respect to a geographic reference system.

spectral reflectance - The reflectance of electromagnetic energy at specified wavelength intervals.

supervised classification - A technique that uses independent information to define training data that are used for classification.

systematic errors - Geometric distortions which are constant and can be predicted in advance.

training fields - Areas on the ground that are similar in composition that are used to train the computer.

unsupervised classification - A discriminatory procedure that uses only the statistical properties of the image data as a basis for classification.

* Compiled by Kenneth E. Mayer and Lawrence Fox III with extensive reference to Remote Sensing Principles and Interpretation, Sabins, 1978.

Executive Review of a Report

"Watershed Condition Inventory of the Hoopa Valley Indian Reservation Utilizing Landsat Digital Data"

By

Kenneth E. Mayer and Lawrence Fox III

Executive Review

By

Donna B. Hankins
Principal Investigator

Remote Sensing & Technology Transfer Project
Humboldt State University
Center for Community Development

In Partial Fulfillment of NASA Grant 2244

March - 1979

ABSTRACT

Landsat digital data, with supporting U-2 aerial photographs and ground truth sampling, was used to map forest land condition and vegetation cover on the Hoopa Valley Indian Reservation. The Landsat digital data was analyzed using the EDITOR software package, which was accessed through a portable computer terminal at Humboldt State University. EDITOR consists of a series of interactive procedures and multispectral classification algorithms based on Multivariate Discriminate Analysis.

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Mixed Forest			. . . .	36%
Hardwood Forest			. . . .	2%
Brush -	80%	Crown Closure	. . .	8%
" -	60%	" "	. . .	6%
" -	50%	" "	. . .	7%
" -	40%	" "	. . .	5%
" -	30%	" "	. . .	1%
" -	20%	" "	. . .	7%
" -	10%	" "	. . .	6%
Water			. . . .	3%
Snow			. . . .	1%
			TOTAL	100%

6) The crown closure land condition categories comprise approximately 40 percent of the Hoopa Indian Reservation. The sparse brush or crown closure categories (10% to 30% CC) cover 14 percent and the heavy crown closure (40% to 80% CC) categories cover approximately 26 percent.

INTRODUCTION

It is clear that there are diverse and several types of reporting that go with accomplishing something and then trying to describe what was done. Probably this section should be called "Acknowledgements" - but it is my way of introducing the whole business.

This report represents a synthesis of the final technical report written by Kenneth E. Mayer and Lawrence Fox III. However, I, Donna Hankins, am solely responsible for the contents and accuracy of the Executive Review where it differs from the original. These two gentlemen (with the many faceted cooperative efforts of Gary Rankel, U.S. Fish & Wildlife Service; Mr. Joe Webster, Associate Director of the NASA Grant to HSU; and numerous persons of NASA, Ames Research Center, principally Dr. Dale Lumb, Mrs. Sue Norman and Mr. Dave Peterson) performed the awesome share of the technical and field work and prepared the report from which a great deal of the present "Summary" is drawn.

They are all to be highly commended. The report is complete, the job itself is done, and without many cooperators and helpers, such as the Geography and Topographic Divisions of the U.S. Geological Survey (Mr. William Newland and Mr. Leonard Gaydos, in particular), the task simply could not have been accomplished.

But this report also represents a personal effort to place the sterling work done into its proper, fitting, chronology and perspective - that of a major technology transfer effort begun some time before the actual "project" and which will not be finished within the lifetimes of many who have worked on it.

The "thanks" for this effort go directly to the citizens of the Northern California Interim Task Force who had courage and energy to reach out, just as NASA's national outreach effort was beginning, to grasp a technology and make it begin to work for them. Thanks, too, must go to NASA's planners-in-chief for the Regional Applications Program which made the project possible.

Finally, appreciation must be given to the person who truly helped make it all happen - Mr. Ben Padrick, of NASA Ames Research Center. His role has been to be the "starter" for the engine of technology transfer in Northern California, and to him go my deepest thanks for his energy, enthusiasm and support during the difficult and formative period of this effort.

Hopefully, the Executive Summary will be readable as well as technically correct. For this, I heartily thank my colleague, Kamila Plesmid, and her considerable translative and grammatical skills, along with strong editing policies. For technicalities I must again thank, with affection, Ken Mayer and Larry Fox.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS IN ORDER OF APPEARANCE

* Economics of today unfortunately do not permit reproducing in their original beautiful and useful form the color photographs prepared by NASA Ames Research Center as part of their contribution to the project. I have elected to reproduce the photos in color Xerox form, which give an excellent idea of what these products are like, and at least double the number of people that can receive this report.

THE PROBLEM - THE FISHERY DECLINE IN NORTHWESTERN CALIFORNIA

Populations of salmon and steelhead in the coastal rivers of northwestern California have declined dramatically in recent decades. Northern rivers which once supported commercial harvests in excess of one million pounds annually, now contribute much less to the catch. Chinook salmon runs of the north coast dropped from an annual average of 255,000 during 1940-49 to 91,000 during 1960-69, a 64% loss; coho salmon runs have fallen from 147,000 to 57,000 or a 61% loss; and steelhead from 290,000 to 100,000, a 65% loss. Despite these count figures, very limited data exists regarding the status of anadromous populations, relationships between the populations and their environment and contributions of populations from various river systems. (Rankel, 1977.)

The Trinity River, principal tributary to the Klamath River, flows approximately 180 miles across northern California to its junction with the Klamath River at Weitchpec from which it proceeds 42 miles in a northerly direction to its junction with the Pacific Ocean at Requa. The Klamath River within California has a drainage area of 7,870 square miles and is the largest watershed in northern California. The Trinity River Basin comprises 2,965 square miles of which the upper 720 square miles has been rendered inaccessible to anadromous fish runs since 1963 with the completion of Lewiston Dam, constructed as part of the Trinity River Division of the Central Valley Project. Located 111 river miles upstream from the mouth of the Trinity River, the dam has led to annual exports of Trinity River water to the Sacramento Valley amounting to reductions in average annual flows past the dam site of approximately 88 percent and reductions in peak flows from over 70,000 c.f.s. to 250 c.f.s., except during infrequent spill periods. The post-project water release regime has resulted in water temperature modifications, sediment buildups and riparian vegetation encroachment in the river below the dam leading to further reductions of useable habitat.

The Klamath-Trinity River System has historically supported large runs of salmon and steelhead which in turn have sustained important inland sport and Indian subsistence fisheries and contributed to offshore sport and commercial catches. As a result of the Trinity River Division Project, man's activities (logging, road building, fishing, etc.) and natural processes (geologic instability, high rainfall and floods such as the 1964 occurrence), anadromous fish runs in the system have declined drastically in recent years as reflected by reduced angler and Indian harvests and diminished returns to the Trinity River Fish Hatchery.

The lower 16 miles of the Trinity River and lower 42 miles of the Klamath River flow through Indian lands of the Hoopa and Yurok tribes. Generations of Indians have utilized fishing grounds in the rivers, and their fishery for salmon and steelhead has historically provided the mainstay of Indian economy in the area. Perpetuation of this valuable resource is of vital concern to the Indian community and the tribes recognize that all competing resource-user groups must work together to prevent further deterioration of the runs.

The California Department of Fish and Game (CFG) in conjunction with the Trinity River Task Force (TRTF) has undertaken a program to identify and correct salmon and steelhead problems in the Trinity-Klamath River Basin. To be complete, such an effort had to take into account the 58 miles of river flowing through Indian land (over one-third of the total river miles involved) and approximately 250 miles of associated tributary streams located on the Hoopa and Klamath Reservations, many of which support spawning runs.

The U.S. Fish and Wildlife Service (FWS) had gained previous experience with problems of the Trinity River Basin through its ongoing fishery management assistance program on the Hoopa Indian Reservation and through participation in the TRTF. Adoption of the data collection plan with FWS doing the work would lead to a greater degree of involvement in ongoing basin-wide programs and through coordination with BIA, CFG, TRTF and other interested agencies and groups as part of the basin-wide approach.

FWS involvement was initiated through establishment of a Fisheries Assistance Office in Eureka, California in January, 1977. The office was initially set up at the Cooperative Fishery Unit, Humboldt State University and Gary L. Rankel, Biologist-in-Charge, U. S. Fish and Wildlife Service was stationed there on a permanent basis. (The office has subsequently moved to Jacoby Building, Suite S, 791 Eighth Street, Arcata, CA. 95521.) The office is administered by the Fisheries Assistance Office, Reno, Nevada. A field office was also established on the Hoopa Valley Indian Reservation.

Terms and Acronyms:

c.f.s. - cubic feet/second

TRTF - a federally funded multi-agency group (12 agencies - state, federal and local) formed in 1973 to take interim action and prepare long-term plans for rehabilitation of the Trinity River Basin.

WHEN THE PROBLEM BECAME AN OPPORTUNITY

An acute and long term awareness of the complex and overlapping requirements in the areas of forestry, water and land use led a group of Humboldt County citizens to form an ad hoc task force in 1975 to address the inherent problems in each discipline. As a result of the training and background of certain task force members, combined with increased national attention focused on the important role of NASA technology and Remote Sensing in similar problem areas in the states of Washington, Oregon and Idaho, the task force had centered its interests on bringing applications of space technology and remote sensing information to those problems.

Mr. Gary Rankel, of the U.S. Fish and Wildlife Service, was invited to present the FWS problem he was working with on the Hoopa Reservation to the Northern California Interim Task Force.

Similar problems affect and involve nearly all elements of the northern California community at large; i.e., cities and towns, the counties themselves, and include the total living natural environment of forests, rivers, mountains, coastal lands and oceanic shelf.

The natural environment, so vital to the overall social and cultural patterns of the region, influences and affects small city populations, labor and employment patterns of the large private and public timberlands, the extensive Native American population of northern California and their large tribal land holdings, along with all other sectors of the human environment of the region. Thus, there is a demonstrated need for development of the best possible resource and human plans for this region, known for its natural beauty and splendid environment but burdened with one of the highest unemployment rates in the nation.

These diverse factors were prevalent in the northern California community for many years, and developing in those same years was the science of remote sensing. The National Aeronautics and Space Administration (NASA) had long since done research and development of all background and technology necessary for space travel and to get humans on the moon. Recently, a dynamic change in key activities on the part of NASA took place. As of early 1977, the mandate was to initiate and develop regionally oriented remote sensing applications and training programs out of three lead centers--Goddard Space Flight Center at Greenbelt, Maryland; Earth Resources Laboratory at Slidell, Louisiana; and Ames Research Center at Moffett Field (Bay Area), California. Each of these centers was directed to work with State and local communities--helping them solve various resource problems as they, the communities, saw them, but utilizing the technology of remote sensing as a new information gathering device and as a powerful analytic tool. Cooperative, cost-sharing projects were to be developed on a selected basis, as a way to demonstrate the utility of remote sensing data for such problems. These regional efforts were named the Regional Applications Programs (RAP). The one in the West, of course, became WRAP.

Given the goals and objectives of the new NASA directives, and the perceived goals and objectives of the citizens task force of northwestern California, a need for development of a model for technology transfer to regions and communities was jointly conceived by the northern California task force and representatives of the NASA team at Ames Research Center. As initial work on the "model" was undertaken by the task force, it became imminently apparent that a need existed for a special facility and philosophical environment in which to actually do the work. The Center for Community Development, an arm of Humboldt State University, was chosen as the ideal setting for the essential, broad-based, small community interaction with NASA, an agency dealing in very high technology.

In such an interaction, a bridge to be established would be between the technology and the people who could and would use it. The Center for Community Development, with its unique access to the expertise, facilities, students and staff of Humboldt State University, yet solidly linked to the numerous pressing community problems of the quarter million citizens living in its six-county 20,000 square mile service area, provided a logical local site with the internal philosophy necessary to the successful accomplishment of such a diverse project. During its nine-year history, the Center's personnel and directorate had demonstrated the ability of the facility to act as a community catalyst in well over 100 separate community oriented projects and programs.

As one step in the "Building a Model for Technology Transfer in Northwestern California" project, Humboldt State University's Center for Community Development, in cooperation with the National Aeronautics and Space Administration, held a Conference on April 6, 7, and 8, 1977, in Eureka, to address the above complex issues and begin applied research on a "model" for technology transfer. The Conference, titled, Exploring the Use of Aerospace Technology in Solving Some Resource Based Problems in Northwestern California, provided a general forum of discussion to facilitate free interaction between participants concerning information about remote sensing, as an information gathering tool, and application techniques of the technology in several disciplines.

Gary Rankel, along with a panel of six other agency and tribal representatives, presented his project. Each of these panelists discussed a different specific resource problem, and stated that they were attending the conference to examine the potential for using remotely sensed data as a part of the solutions.

Action Plans were developed at the Conference, April 6, 7 and 8, 1977, and are tabulated in order of priority as expressed by the Conferees.

1. To establish a local training and education program to encourage users assistance, and the transfer of remote sensing knowledge to local communities.

   Involved in the above is the development of a "Core Group" to
   a. gather remote sensing materials and develop a remote sensing service;

b. educate users as to what is available, how to obtain, and how they can use remote sensing materials; and,
c. to establish an unincorporated/nonprofit northcoast remote sensing resource center to provide the following services or facilities,
    1. library
    2. training
    3. browse file
    4. problem recognition for public boards and county agencies, and industry technical transfer.

II. To develop, study, and analyse the moral, ethical, equity questions and guidelines for the application of remote sensing materials with (a) clear and definite limits to policing and regulatory applications, and (b) requiring economic analysis to approach the sophistication of the hardware (cost effectiveness and established guidelines). Analysis should also consider the appropriateness of discontinuing remote sensing programs and, instead, funding local conservation/restoration programs for action NOW.

III. To select a small area with the largest number of users and disciplines and to (a) maximize data base at minimum cost, and (b) develop a test site for overlap studies.

IV. Establish a task force to develop projects for northern California, using this conference information and based on legislation and commonality of informational needs.

V. Link the President's Science Advisory Committee to existing local extension agent, and to establish a State remote sensing center to:
a. inventory local resources,
b. establish a catalog of remote sensing data,
c. promote training courses and programs,
d. publish a newsletter or trade magazine, and
e. provide local availability of data.

All of the items developed have seen action and forward motion. Description of such activities can be found in Building and Developing an Institutional Mechanism for Technology Transfer Using Northern California as a Test Site - A Final Report - NSG 2244. The exception is the #III item above, "selecting a small area with the largest number of users and disciplines, maximizing data base at a minimum cost, and developing a test site for overlap studies." The report which follows, A Watershed Condition Inventory of the Hoopa Valley Indian Reservation Using Landsat Digital Data, represents the completion of that action item.

For information on how to obtain the above two reports, please contact NASA Remote Sensing and Technology Transfer Project, Humboldt State University, Arcata, California 95521. 707-826-3112.

THE DEMONSTRATION PROJECT

Following the April 1977 conference, a grant was made to Humboldt State University, the Center for Community Development, as a way to facilitate training, technical projects and other technology transfer activities in northern California. Several discussions took place between the U.S. Fish and Wildlife Service, represented by Mr. Gary Rankel of Eureka; the National Aeronautics and Space Administration, represented by Mrs. Susan Norman, California Western Regional Applications Program (WRAP) coordinator, of NASA, Ames Research Center; and the Humboldt State University Remote Sensing and Technology Transfer (RSTTP) grant staff, represented by Ms. Donna Hankins, principal investigator, and Dr. Lawrence Fox, III, technical advisor.

The initial problem was to determine portions of the Hoopa Square study where direct application of Landsat technology would be suitable.

By Fall of 1977, letters of understanding were exchanged between the U.S. Fish and Wildlife Service and NASA Ames Research Center outlining conditions, tasks, responsibilities and administrative guidelines for all those involved, including HSU grant personnel.

The RSTTP provided overall administrative and coordinating functions between the three agencies. Humboldt State University, through its Center for Community Development, provided office facilities for the RSTTP for the duration of the project. RSTTP was funded by the ARC-Western Regional Applications Program (WRAP), with a substantial portion of those funds set aside to complete this project.

NASA ARC provided:

- Technical coordination/consultation for all phases of the project
- Technical facilities and personnel for training of USFWS and HSU participants
- Computer facilities and analysis support materials
- Output product generation.

U.S. Fish and Wildlife Service provided:

- Biological technician support (130 day position)
- Access to ground data in conjunction with the Bureau of Indian Affairs and Hoopa Indian Tribal Council, Hoopa, California
- Consultation and coordination of activities in collection of ground data and other supplementary materials.

The next ten weeks were spent in intensive training and orientation to both remote sensing technology and the field area for project participants.

Searches were made for existing USGS Quadrangle Maps in 7½ minute format; existing U2 and other photography over the study area; and Landsat data tapes of a seasonal time that would best show differentiation of various vegetation and bare soil classes.

During this period, it was decided that a computer terminal at Humboldt State University (grant offices at Center for Community Development) connected by a WATS telephone line to the main computer system at NASA Ames Research Center, would serve to accomplish most computer training and the actual project work itself which needed computer processing. By early 1978, a solid, technical operating plan had been developed, equipment was in place, responsible personnel designated, and the project itself was ready to begin.

The Study Area - Land, People and Fisheries

The Klamath River watershed is a heavily forested area containing large stands of virgin timber, and draining approximately 15,600 square miles (25,100 km^2) in Oregon and California. The majority of the drainage in California lies within the boundaries of the Six Rivers, Klamath, Shasta and Trinity National Forests. The lower 42 miles (67 km) of the Klamath River and lower 16 miles (26 km) of the Trinity River lie within the confines of the Hoopa Valley Indian Reservation.

The Klamath River flows westward from Iron Gate Dam, joins with the Shasta and Scott Rivers and then turns southward and unites with the Salmon River. After joining with the Trinity River, its largest tributary at Weitchpec, the Klamath River changes course and flows in a northwestward direction before emptying into the Pacific Ocean near Requa, California.

Throughout most of its course the Klamath River and its major tributaries, the Trinity, Shasta, Scott and Salmon Rivers flow in steep V-cut valleys, between steep mountainous ridges. This feature, along with numerous riffles and "nickpoints" (small waterfalls), is indicative of rapid downcutting of the rivers through the underlying rock units.

In the study area, major rock units from east to west are the Galice, South Fork Mountain Schist and the Franciscan. (Bulletin 190 - California Division of Mines and Geology, 1964.) The units are complexly faulted and fractured and due to this feature, contribute large amounts of clay rich sediment to the river system.

The Trinity River drains 2,970 square miles (4,778 km^2) while the Shasta, Scott, and Salmon Rivers each have drainage areas comprising approximately 800 square miles (1,287 km). Precipitation averages 40 inches (101 cm) annually throughout much of the basin and can exceed 90 inches (229 cm) per year along the coast. Precipitation gradually decreases inland to approximately six inches (15.2 cm) annually in the eastern portion of the basin.

The Hoopa Valley Indian Reservation comprises approximately 144,000 acres (58,299 ha) in Humboldt and Del Norte Counties, California. That portion of the reservation referred to as "The Square" (Fig. 1) comprises 90,000 acres (36,437 ha) and is generally mountainous and rugged, ranging in elevation from 320 feet (97.5 m) to over 5,000 feet (1,524 m). Steep mountainous terrain comprises approximately 97 percent of "The Square" while the remaining area, the Hoopa Valley, is a low alluvial plain, which borders the Trinity River.

Climatic conditions in this area vary appreciably with rainfall averaging approximately 49 inches (124 cm) per year in the higher mountains near Weitchpec. Snowfall is negligible adjacent to the Trinity River but is substantial at higher elevations. Temperatures vary from mean January and July values of 54 F (12.2 C) and 70 F (21.1 C), respectively, with extreme variations to 16 F (-8.8 C) and 102 F (38.9 C). Soils fall within the broad vegetational class referred to as the Douglas Fir-White Oak prairie type. The timber covered terrain provides desirable habitat for blacktail deer, bear, quail, grouse and many fur bearing animals. The economic base of "The Square" is centered around the timber industry with large stands of Douglas fir providing the principal resource.

The two tribes which reside on the Hoopa Valley Indian Reservation include the Hupa Indians of "The Square" and the Yurok Indians who occupy land along the lower 42-mile (67.5 km) stretch of the Klamath River, frequently referred to as "The Strip." The original Hoopa Valley Reservation (that portion referred to as "The Square" created in 1864, was enlarged in 1891 to include a tract of land one mile in width on either side of the Klamath River extending from "The Square" to the Pacific Ocean. This extension incorporated the old Klamath River Reservation or "Lower 20" section created in 1855, into the Hoopa Valley Indian Reservation. Most of the "Lower 10" has since passed into non-Indian ownership, resulting in controversies concerning Indian ownership and rights within the Klamath River section of the reservation. Despite the large private holdings, the U. S. Supreme Court in 1973 held that the "Lower 20" portion was still considered "Indian Country."

Land-conditions and environmental factors along "The Strip" are similar to the Hoopa Square. The Klamath River is characterized by steep canyon walls with slopes in excess of 100 percent. Vegetational communities are similar to "The Square" with the exception of Redwoods which are found near the mouth of the Klamath River. Both "The Strip" and "The Square" contain many tributary streams which provide considerable anadromous fish habitat.

Tribal members of "The Square" have formed a government based on an official tribal roll, which has exercised a broad range of jurisdiction over Indian affairs, including fishing. A gill netting ordinance adopted by the tribe in 1976 prohibits the placement of any gill net which extends beyond two-thirds of the distance across the Trinity River, the placement of any net in front of the mouth of any tributary stream and the taking of fish for commercial purposes. Gill nets must also be lifted and removed from the river on a daily basis.

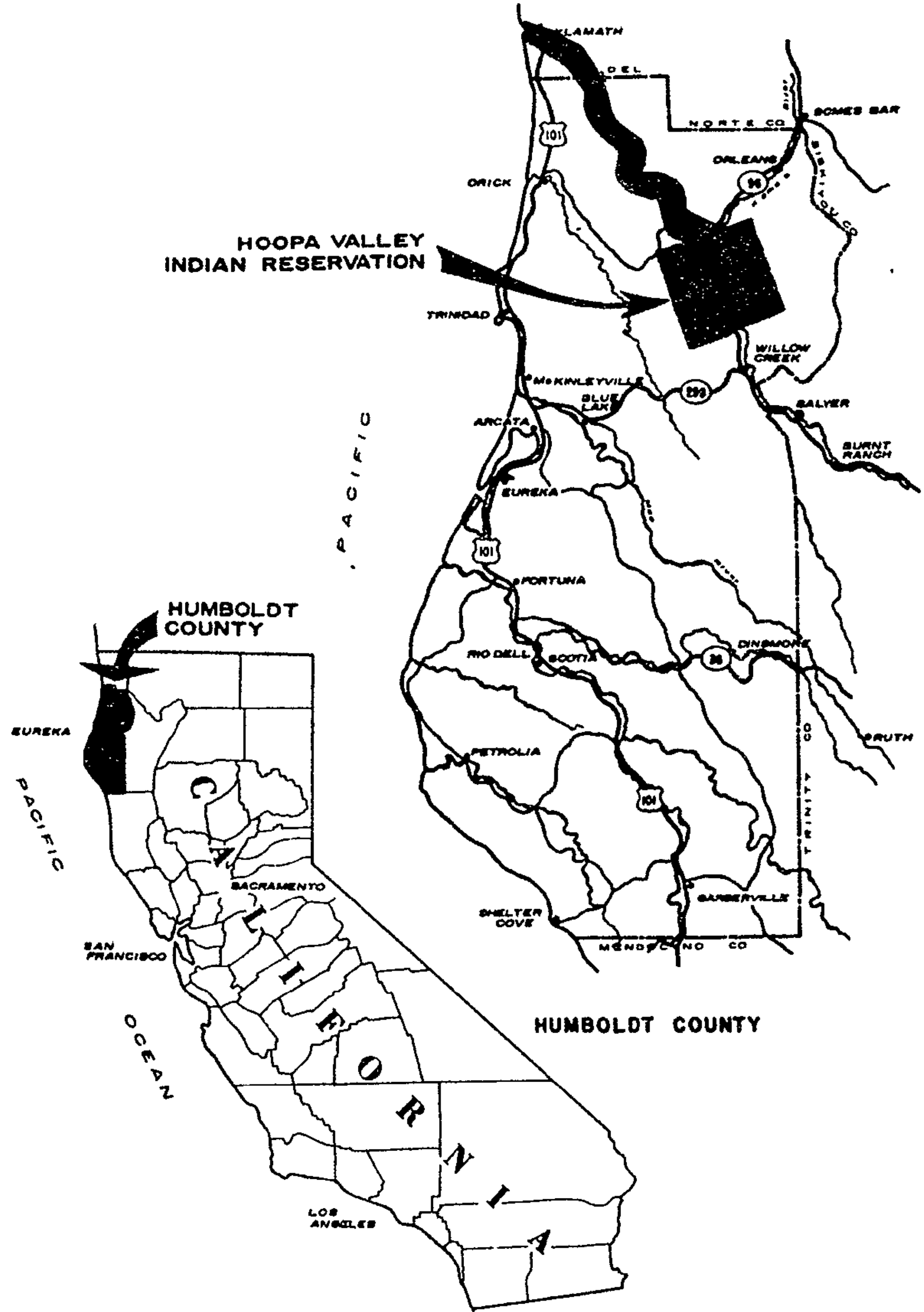


Figure 1. Study area location, Hoopa Square and Klamath Extension.

Unlike the Hupas, the Yurok people have had no officially-recognized tribal government, tribal roll or means of jurisdiction. Their lack of authority to control or regulate individual tribal fishermen has resulted in the current controversy surrounding Indian fishing rights on the Klamath River. An Ad Hoc Fishing Committee, comprised of Yurok Indians was formed in 1975 to advise the Yurok people concerning fishing rights. This committee disbanded in 1977 because of widespread tribal non-support. Attempts are underway by a number of Yurok leaders to form an interim tribal government on the reservation.

The Klamath River basin has historically supported large runs of salmon and steelhead trout, which have contributed considerably to sport and commercial fisheries in California and have provided the mainstay of Indian economy in the area. Heavily utilized trade routes from the interior to the sea, resulted in a lively commerce in dried fish and shells. Much of the ritual and labor of the Indian people was related to the capture and care of salmon and steelhead. The fall chinook salmon run was most important because low river flows and considerable numbers of large fish provided optimum fishing conditions. The flesh of this fish was ideal for smoke curing and storing for winter use. Indians historically constructed fish weirs of logs, poles and brush across the rivers and speared or netted upstream migrants. Weirs remained in place until late fall high flows washed them away. In recent decades, weirs have been replaced by more efficient gill nets which have raised a variety of jurisdictional questions regarding Indian fishing rights.

Biologists with the U.S. Forest Service estimated an annual net economic value of salmon and steelhead fisheries attributable to the Klamath River watershed, exclusive of the Trinity River drainage, of $21.5 million. This value includes sport and commercial fisheries but does not take into account the Indian subsistence fisheries. Average annual values per mile of chinook salmon, coho salmon and steelhead trout habitat within the Klamath National Forest were also estimated at $25,000, $2,300 and $4,500 respectively (Kesner, 1977).

Eight anadromous fishes spend portions of their life cycles in the Klamath River System: chinook or king salmon, coho or silver salmon, steelhead trout, coastal cutthroat trout, brown trout, green sturgeon, American shad, and Pacific lamprey. Small runs of white sturgeon may also occur in the basin (Moyle, 1976). Resident species include native rainbow trout, brown trout, eastern brook trout, and several species of non-game and warm water game fishes. Notable marine visitors include the starry flounder, surf smelt, and redtail surfperch (Rankel, 1978). A review of life history information for respective species along with a summary of temporal run-size trends appears in Rankel (1978).

Landsat Overview

In any reporting of work accomplished, it is important to set out clearly the steps involved, the materials and methods involved, a reasonable chronology of their use, as well as the results obtained.

In this particular project, these elements assume an even greater importance since the technology itself will be judged as to how well it worked in accomplishing the desired objectives, as well as the overall results.

As a result of the intensive planning efforts described earlier, a combination of remote sensing technical tools and conventional data were selected - principally, Landsat digital data, U2 high altitude infrared photography, USGS 7½' maps and ground verification.

The data to be extracted would be pertinent information on certain resource types (conifers, mixed forest and hardwoods); how they are distributed, in what percentages and where located relative to tributaries of the Klamath and Trinity Rivers.

The objective, above all, was to make no judgments regarding how or why the landscape arrived at its present condition, but to contribute a comprehensive and vital planning base from which interpretations could be made by all involved.

The Landsat data is directly recorded in a digital format on magnetic tape, greatly facilitating the application of computer processing programs.

After a review of the vegetation communities, desired land condition classes and ground truthing time frame, an April 12, 1977 Landsat scene was selected for analysis. A computer compatible tape was acquired from Earth Resources Observation Systems (EROS) Data Center. Radiometric anomalies, including bad data lines and points, radiometric striping and atmospheric scattering were not corrected or normalized before processing. These errors were not significant for the data tape used in this project.

Once preprocessing had been completed, a window was selected from the Landsat scene. The window selected to cover this area was approximately 1,000 pixels (acres) on a side, 1,000,000 bytes of information in each of the four channels.

The U2 Overview

The following U2 information is adapted from "High Altitude Perspective," prepared by the Airborne Missions and Applications Divisions of NASA Ames Research Center in 1977.

The U-2 is a single-place aircraft designed and built by the Lockheed Aircraft Corporation for high-altitude, long-range operation. The U-2 is characterized by its long wing span and tandem landing gear located under the fuselage. Auxiliary gear, called pogos, are located outboard on the underside of each wing; they are jettisoned on takeoff.

The NASA U-2 aircraft, based at Ames Research Center, routinely fly from Ames and Wallops Island, Virginia. Other staging locations are possible, however; for example, data flights have been flown from Hawaii, Alaska, Texas, Maine, South Dakota, and Panama.

The high-altitude, long-duration capability of the U-2 makes it uniquely suitable for upper atmospheric or space-oriented research as well as for wide ranging electronic and photographic Earth observations. Since the beginning of NASA's Earth resources survey program at Ames Research Center in September 1971, each of the U-2's has averaged over 100 flights per year and together they have accumulated over 4000 flight hours.

The U-2 has been used extensively to collect underflight (or "ground truth") data to support Landsat investigations in forestry, water management, coastal zone processes, rangeland management, and land use. Multistage sampling techniques to aid in interpreting satellite data have been developed through the use of U-2 imagery.

The NASA U-2's routinely carry a wide variety of sensors. Included are aerial mapping cameras, electronic sensors and scanners, and both in situ and remote atmospheric sampling devices.

See Figure 2, Camera Configurations, page 14 , and Figure 3, Camera Ground Coverage, page 15.

U-2 photography coverage was obtained over the study area on May 8, 1978, using the RC10 6 inch focal length lens together with the HR732 24 inch focal length lens, using infrared film. This provided suitable, up to date coverage for the purpose of validating the satellite data.

Processing the Data

The Landsat digital data was analyzed using interactive procedures and multispectral classification schemes. The purpose of digital image processing is to group pixels spectrally into a number of meaningful categories that can be correlated to natural resource features.

A special computer software package called EDITOR was used exclusively to carry out these functions.

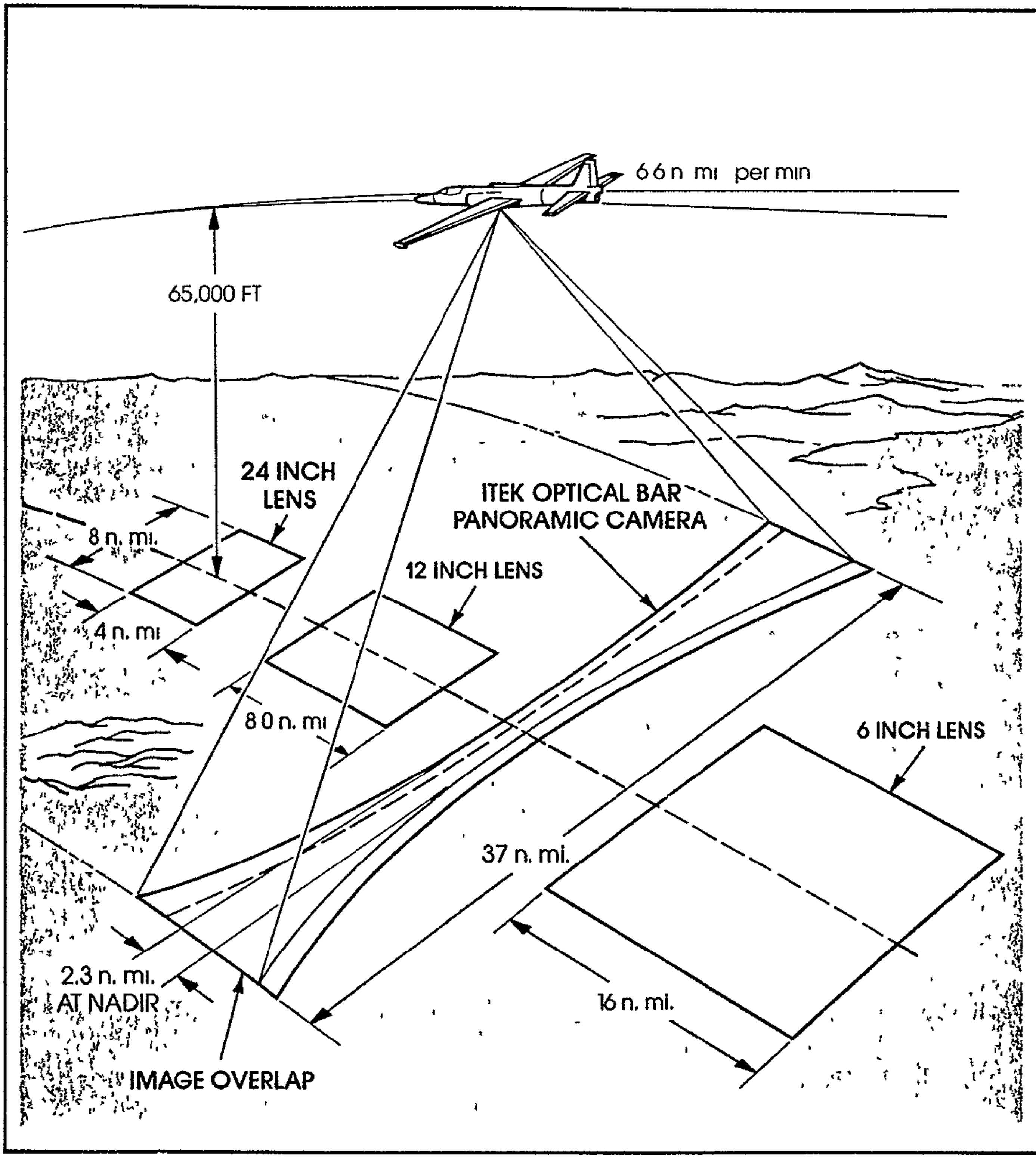
EDITOR is a three-fold system for interactive image processing, file management, and ILLIAC IV high speed central computer interfacing. Interactive image processing allows for the manipulation and display of Landsat digital data by the analyst at a local level using a portable computer terminal.

CAMERA CONFIGURATIONS - FIGURE 2

DESIGNATION	LENS	FILM FORMAT, in	GROUND COVERAGE @ 65,000 ft	NOMINAL RESOLUTION @ 65,000 ft
VINTEN (FOUR)	1-3/4 in FL F 2 8	2-1/4 x 2-3/16	14 x 14 n. mi (EACH)	10 – 20 m
I²S MULTISPECTRAL (FOUR BANDS) K-22	100 mm FL F 2.8	9 x 9 (4 @ 3 5)	9 x 9 n mi	6 – 10 m
RC-10	6 in, F 4	9 x 9	16 x 16 n. mi	3 – 8 m
RC-10	12 in, F 4	9 x 9	8 x 8 n mi	1.5 – 4 m
HR-732	24 in, F 8	9 x 18	4 x 8 n mi	0 6 – 3 m
HR-73B-1	36 in, F 10	18 x 18	5 3 x 5.3 n mi.	0 5 – 2 m
ITEK PANORAMIC	24 in F 3 5	4 5 x 50	2 x 37 n mi	0 3 – 2 m

FIGURE 3

CAMERA GROUND COVERAGE



The first step taken in processing the Landsat scene was an ILLIAC IV unsupervised classification. This process assures that all possible spectral information can be extracted. An arbitrary number of spectral classes (20) was chosen and submitted to the ILLIAC IV for unsupervised classification. The computer assigned alphanumeric symbols to the spectral classes that it selected and a line printer map was produced. The line printer map, at approximately 1:24,000 scale, was useful in determining the geographical location of spectral classes. A two channel map was developed using channels 2 (red), and 4 (infrared). The spectral means of each class were plotted in their respective channels. At this point, it was possible to begin making inferences as to which resource types the classes represented. U-2 photography was used to assign reliable resource labels to the computer assigned classes. See Figure 4.

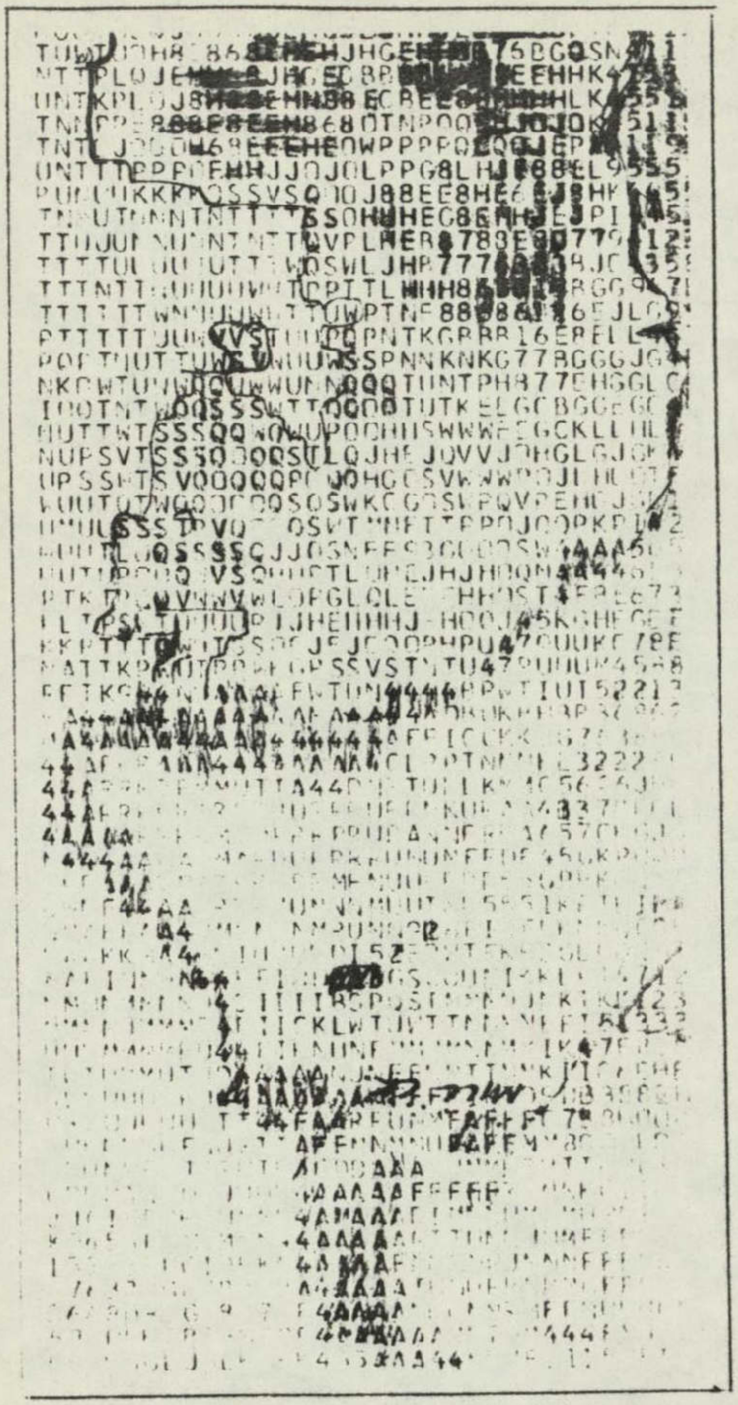
In order to assure accurate location of resource features on the Landsat scene, a calibration file was produced. Unique pixels or control points on the line printer map and their corresponding location on 7½ minute quadrangle maps were recorded and analyzed using least squares regression techniques. Row/column and latitude/longitude of the control points were entered into the computer and were edited. Control point editing is the process by which mis-located points are eliminated to achieve accuracy of within one pixel (80 m) of the true location. The calibration file standardized the Landsat scene to United States Geological Survey (USGS) quadrangle maps. This insures accurate location of resource features as well as training areas.

The next step was to produce a supervised classification of the study area.

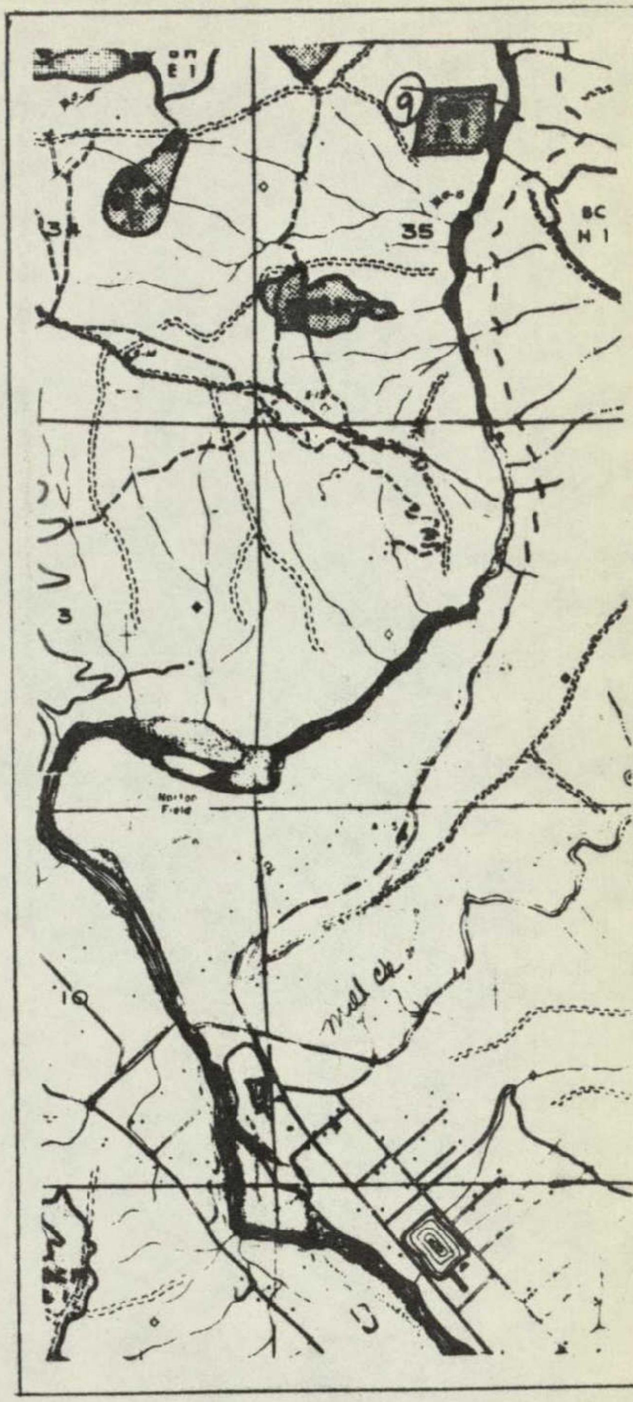
Supervised classification with guided clustering uses independent information to define statistics that establish classification categories. Areas were selected that were spectrally alike (homogeneous) for each resource type. The process of guided clustering enables the analyst to account for spectral differences (heterogeneity) within a training field. A vegetation cover type may be homogeneous in terms of resource category definition, but may contain several spectral signatures.

Approximately 100 training fields were selected and recorded on USGS 7½' quadrangle maps and labeled according to resource category. The training fields were digitized, labeled and stored in the computer for post classification processing. Each quadrangle map became a digitization segment. The segments, as well as the irregular polygon training fields within them, were stored in computer memory. Ground truth for each field was recorded and each segment was grouped or "packed" into files containing like ground truth information. Each pack file was labeled as to resource type or category represented.

Figure 4 - Unsupervised Line Printer Map and Conventional Map Comparison



A section of unsupervised line printer map showing a bend on the Trinity River in the Hoopa Valley. This distinctive feature helped to distinguish the alphanumeric symbols assigned by the computer to the water and water-land interface along the river (A and 4). Once this bend and its symbols were identified, it was then possible to begin making inferences as to which resource categories some of the nearby classes represented.



A section of a map showing the same bend on the Trinity River. A few cut block sections, roads and drainage creeks can be seen at top and lower left, while a mill pond and urban features of the Hoopa Valley are at left center.

```
        1326 HISTOGRAM POINTS   MIN. PIXEL VALUE= 7  MAX. PIXEL VALUE= 34  (BAND 5)
  BRIGHTNESS VALUES
    7+XXX
     +XXXXXXXXXXXX
     +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   10+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXXXX
   15+XXXXXXXXXXXXXXXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXXXXXXXXXXX
     +XXXXX
     +XXXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXXXXXXXXXX
   20+XXXXXXXXXXXXXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXXXXXXXXXXXXX
     +XXXXXXXXXXXXXX
     +XXXXXXXXXXXXXXX
   25+XXXXXXXXXXXXX
     +XXXXXXXX
     +XXXXXXXXXXXX
     +XXX
     +X
   30+XX
     +X
     +
     +X
   34+X
     +----+----+----+----+----+----+----+----+----+----+----+----+----+----
     0    5    1    1    2    2    3    3    4    4    5    5    6
               0    5    0    5    0    5    0    5    0    5    0
                         2 PIXEL (S)
```

Brightness values for each spectral class displayed as a histogram to aid in cluster selection.

Figure 5

282

NUMBER OF POINTS IN EACH CLUSTER:

```
205  247  182  166
(1)  (2)  (3)  (4)
```

CLUSTERING CLASSIFICATION

```
        1111111111111111111111111111111111111111111111111111
        2222222222222222222222222222222233333333333333333333
        6677777777778888888888999999999900000000001111111111
        8901234567890123456789012345678901234567890123456789

1796    2221122221232212234333223222322222234334422111122233
1797    1111122212212212223332211222322222233433344211111111
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1800    2221322222211222222222233444444433311133333443311112
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1802    2222222222222112222333232121111211111322112231111222
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1810    3333332443443333334444444431123234443332222212222222
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SEPARABILITY MATRIX

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1 + 1.00
2 + 0.66 1.00
3 + 1.26 0.73 1.00
4 + 1.61 1.23 0.59 1.00
  +  +    +    +    +
     1    2    3    4
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Figure 6. Computer generated line printer map and separability matrix depicting individual classes and their approximate location on the ground. This is used in identifing resource categories and the separability of each spectral class.

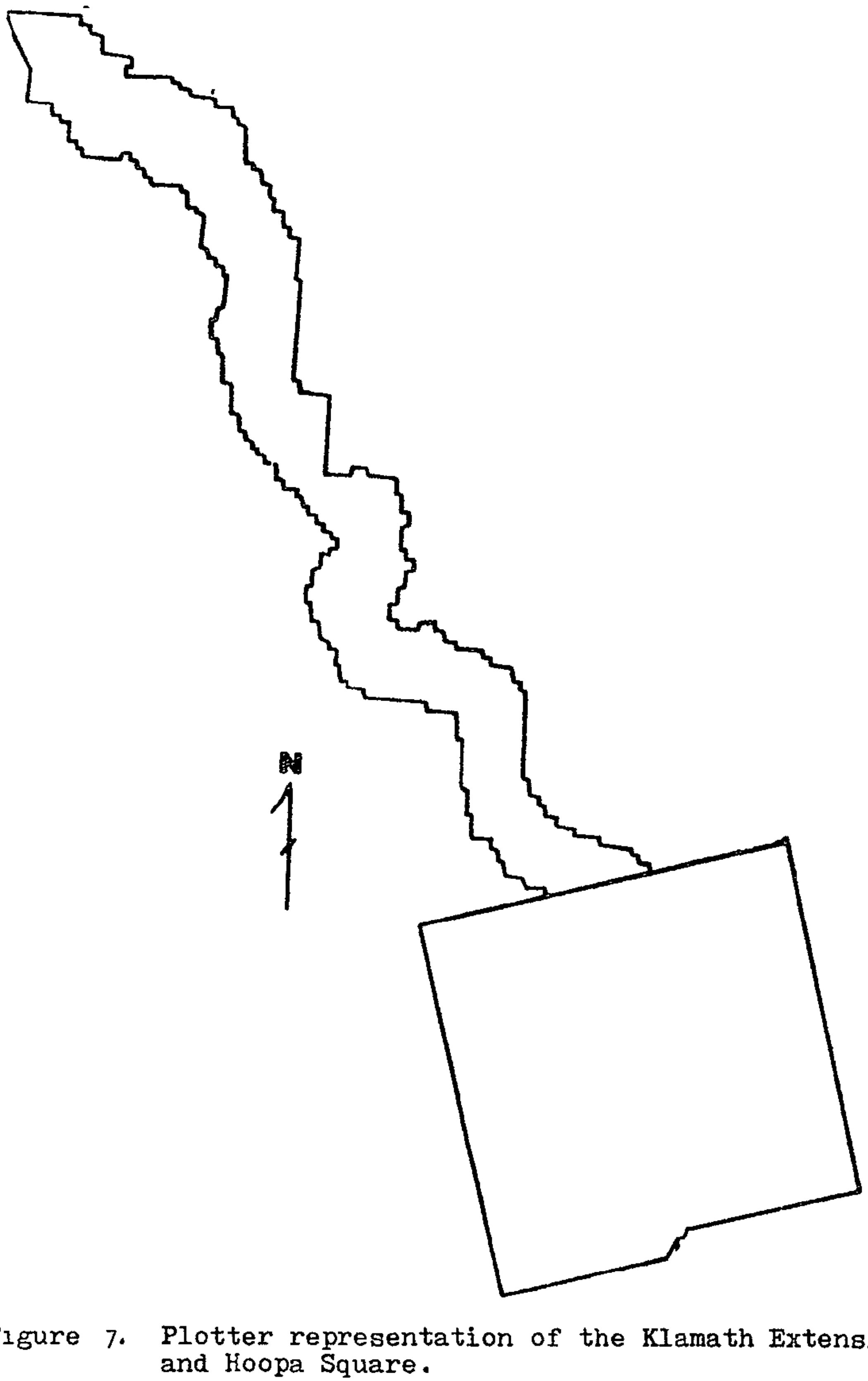


Figure 7. Plotter representation of the Klamath Extension and Hoopa Square.

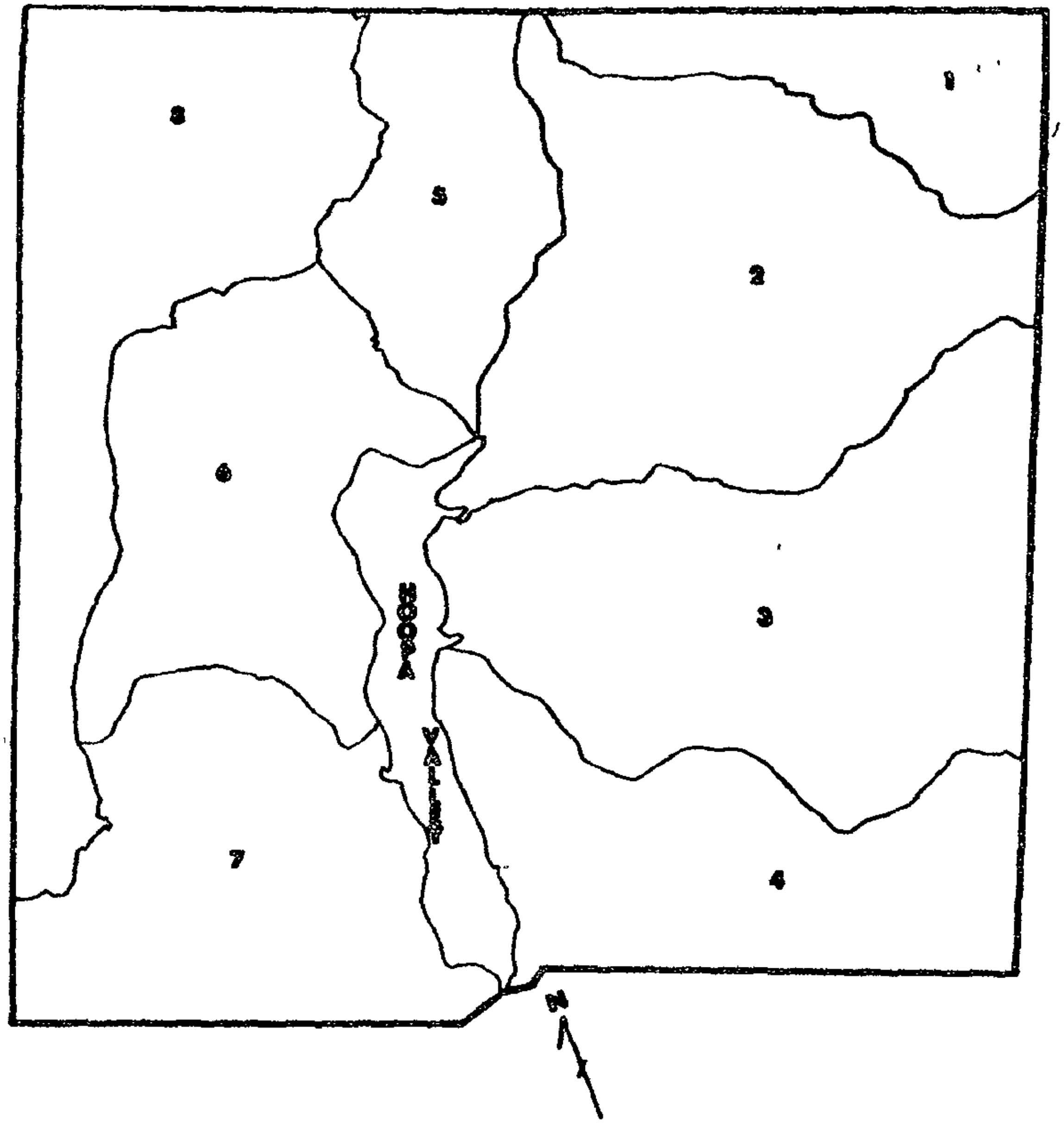


Figure 8. Plotter represention of the eight management units, Hoopa Square.

Field Data Collection Techniques

Field data or ground truth was collected for each land condition category. The study area was divided into sub-sections in order to expedite the field data collection process. These sub-sections had been previously delineated by the B.I.A. at Hoopa and were outlined in comprehensive logging maps. These were then used to direct the collection of ground truth data.

Aerial photographs of the area were examined to determine the types of land condition categories present (Figure 9). These categories were then aggregated together and a representative sample was chosen for field inspection.

Each field plot visited was inspected for plant species composition, soil condition, erosion potential, aspect and slope. Furthermore, each field plot was visually inspected and an occular estimation of the percent crown closure was made.

These field plots became training fields for the classification and were used to standardize the airphoto interpretation when used for further ground truth collecting. Approximately 80% of the ground truth information was collected from airphotos. This provided for quick and consistent data collection that could be easily verified or duplicated.

Evaluation

The Landsat classified scene (April, 1977) was evaluated using U-2 color infrared photography (May, 1978). A nine by eighteen inch format transparency (1:32,500) of the Hoopa Valley and adjoining forest land was enlarged and printed to match the 1:24,000 scale of the line printer map.

The evaluation site was selected to be representative of the study area and contained all of the major cover categories defined in the classification. The site was also adjacent to a unique meander in the Trinity River which facilitated accurate pixel location.

A black line grid was produced on clear mylar to allow an accurate fit to the line printer map. Each grid square represented the size of a pixel at the scale of the line printer map. The grid was placed on the classification and prominent geographical features (e.g., the Trinity River) were identified and labeled. The grid was then placed on the photograph and rotated until a local fit was established, matching geographical features. Pin marks were placed on both products to assure registration.

Figure 9 - U2 Aerial Photograph in the Study Area

The mylar grid was divided into a series of nine by nine inch pixel sampling clusters, eliminating those which had pixels occurring outside of the photograph. Clusters were selected at random and sampled without replacement. The mylar grid was locally fit to the photograph to allow for relief displacement errors. Photo-interpretation was used to evaluate each pixel as to its true land cover category and if the Landsat classification was correct. A pixel count per class sampled was also recorded to insure adequate sample size. Errors of omission and commission were calculated and point estimations of the mean probability of correct classification were determined.

The classification was aggregated as to Landsat class using the NASA IBM 360 computer. The "Hoopa Square" was aggregated separately from the "Klamath Strip". "The Square" was also divided into the management units and summary statistics were produced. The aggregation statistics were accessed through the EDITOR software. Summaries of the number of acres, hectares, and pixels occurring within each class were calculated per area.

Results of the Work

Land condition categories were identified by percent crown closure. Crown closure was defined as the proportion of ground covered by perennial plants.

Erosion in 100% - 40% areas seemed to be low. However, each site has the potential for extreme mass wastage, as erosion is site specific in this region. It was found that erosion increased as the percent crown closure decreased. The 30% category was a prime example of this as evidence of surface erosion was present.

Categories 20% and $<$10% exhibited the highest potential for erosion. The 20% crown closure category was relatively unstable even though covered partially by vegetation. The bare soil category, $<$10% crown closure, was very unstable with little or no ground cover. This condition was usually a result of recent logging or land slides from various causes.

See Table 1 which follows.

Table 1 - Resource Category Descriptions

Category	Map Color	Spectral Class	Description	Erosion Potential[b]
100% CC[a] Conifer	Dark Green	H, 2	Primarily Douglas Fir	Low
Mixed	Green	3,C,J, K,L	Some Conifer/Hardwood/Brush	Low
Hardwoods	Light Green	M	Tan Oak, Madrone, Black Oak, White Oak, Big Leaf Maple	Low
80% CC	Brown	A	Predominantly Ceanothus, little bare soil	Low
60% CC	Tan	F,B,0	Predominantly Ceanothus, little bare soil	Low-Med
50%	Peach	9	Predominantly Ceanothus, successively increasing bare soil	Low-Med
40%	Yellow	4,D E,G	Predominantly Ceanothus, scattered small perennials	Mid-point Medium
30%	Pink	H	Little residual vegetation, visible surface erosion	Med-High
20%	Light Red	7,8	Little residual vegetation, visible instability, slides	Med-High
10%	Red	I	Little to no residual vegetation	High
Water	Blue	N	Ocean, river, tributaries, lagoons, ponds	N/A
Snow	White	5,6	Mountain tops - Not in study area	N/A
Hoopa Valley	Grey		Valley floor - not part of study	N/A

(a) Crown Closure

(b) Site specific erosion - see discussion above.

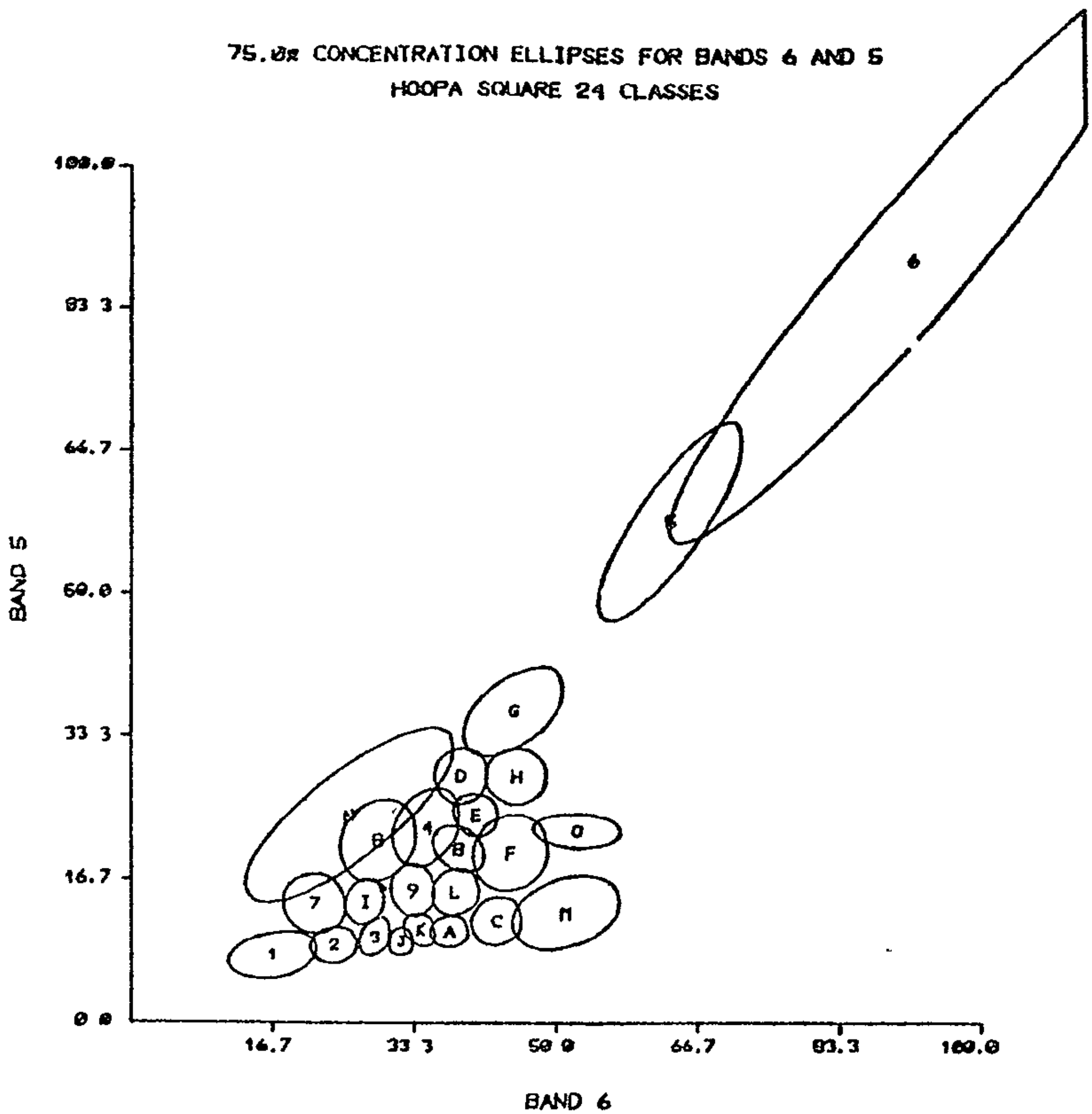


Figure 10. Plotter graph of the final 24 spectral classes in two bands, Band 5 (Red .6 - .7μm), Band 6 (IR .7 - .8μm).

Color coded final map products were developed by first extending and then color coding information developed on the training sites, to the entire area within the digitized boundaries. These photo-map products were designed to best assist the FWS in making regional observations and planning for the next phases of their overall study. They are to be used in close connection with all resource category descriptions and tabular area summaries.

Figure 11 is a pictorial representation of the Hoopa Square and Klamath Extension. The white lines are the political boundaries of the study area that were stratified into the scene. Ground truth and classification evaluations were completed only within those lines. Signature extension was used to classify the remaining area for which no field work had been completed, and consequently was not evaluated.

Figure 12 is an enlargement of the Hoopa Square. Again, the white lines represent the boundaries of "The Square" as well as the management units. The color scheme for both products is identical.

At this scale it is possible to examine the forest cover in detail. Timber management maps are available through the B.I.A. at Hoopa and can be used to correlate land use with the Landsat categories.

A mylar overlay of cut block patterns in "The Square" at the same scale as a large photographic blow-up was prepared to illustrate this point, and delivered to the FWS. An example of how this can be used is to study the cut blocks, as mapped by the B.I.A. They depict a year by year record of the cuts and are coded by year. Visual examination of various bare soil resource categories on the color coded map beneath can quite rapidly identify the areas on the watershed which belong in the categories.

Pixels, acres, and hectares per class per area were calculated. The "Hoopa Square" was divided into eight arbitrary management units and area summaries were developed. The Klamath Extension was calculated separately. The Hoopa Valley was not included in the summaries because of the interest in forest condition and not urban development. Thus, the valley floor was separated from the study area and not included in the classification. Through the use of guided clustering and the pooling of supervised and unsupervised statistics, a high accuracy was attained, averaging 92% overall. The study area was relatively small, allowing for more intensive field work and higher accuracy.

See Table 2 which follows.

Table 2

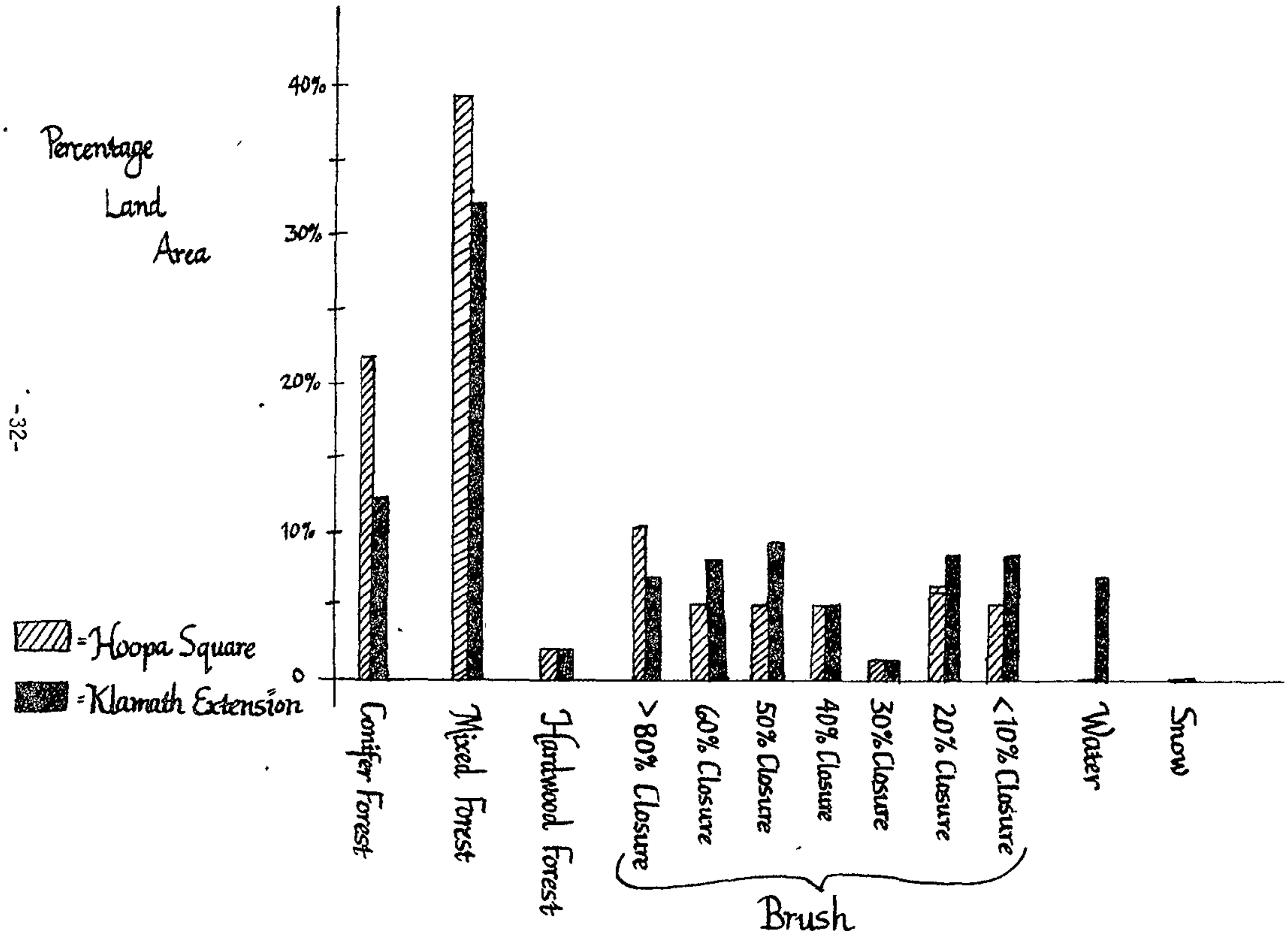
Area Estimation of Landsat Categories per Management unit, Hoopa Square, Klamath Extension.

Fields	1	2	3	4	5	6	7	8	Total	Klamath Extension	
Conifer	1646	2780	4227	2171	302	1100	1659	2910	16795	6080	P[a]
	1844	3114	4734	2432	338	1232	1858	3259	18811	6810	A[b]
	746	1260	1916	984	137	499	752	1319	7613	2756	H[c]
Mixed	1188	5144	4639	3194	2752	4501	3231	4301	28950	16577	
	1331	5761	5196	3577	3082	5041	3619	4817	32424	18566	
	538	2332	2103	1448	1247	2040	1464	1949	13121	7514	
Hardwoods	135	555	189	111	113	132	175	260	1670	1230	
	151	622	212	124	127	148	196	291	1871	1378	
	61	252	86	50	51	60	79	118	757	558	
>80% CC[d] Brush	245	1712	898	1073	719	932	780	867	7226	3051	
	274	1917	1006	1202	805	1044	874	971	8093	3417	
	111	776	407	486	326	422	354	393	3294	1383	
60% CC Brush	227	713	326	313	292	483	835	505	3694	4174	
	254	799	365	351	327	541	935	566	4138	4675	
	103	323	148	142	132	219	378	229	1674	1892	
50% CC Brush	159	518	783	450	382	649	690	487	4118	4294	
	178	580	877	504	428	727	773	545	4612	4809	
	72	235	355	204	173	294	313	221	1867	1946	
40% CC Brush	161	652	535	290	296	226	723	588	3471	2511	
	180	730	599	325	332	253	810	659	3888	2812	
	73	296	242	131	134	102	328	267	1573	1138	
30% CC Brush	45	100	58	27	41	5	92	59	427	497	
	50	112	65	30	46	6	103	66	478	557	
	20	45	26	12	19	2	42	27	193	225	
20% CC Brush	422	690	1029	613	106	199	557	817	4433	4031	
	473	773	1152	687	119	223	624	915	4966	4515	
	191	313	466	278	48	90	252	370	2008	1827	
<10% CC Brush	210	482	998	547	141	471	516	523	3888	3657	
	235	540	1118	613	158	528	578	586	4356	4096	
	95	218	452	248	64	213	234	237	1761	1658	
Water	10	47	32	24	28	5	16	10	172	3412	
	11	53	36	27	31	6	18	11	193	3821	
	5	21	15	11	13	2	7	5	49	1547	
Snow	0	2	114	5	0	7	1	0	129	30	
	0	2	128	6	0	8	1	0	145	34	
	0	1	52	2	0	3	0	0	58	14	
Total	4448	13395	13828	8818	5172	8710	9275	11327	74973	49544	
	4981	15003	15488	9878	5793	9757	10389	12686	83975	55490	
	2015	6072	6268	3996	2344	3946	4203	5135	33979	22458	

[a] P = Pixels [c] H = Hectares

[b] A = Acres [d] CC = Crown Closure

Mean probability of correct classification errors of omission and comission are 91 6% and 91 4% respectively.



Graph Prepared by Dr. Lawrence Fox III

Figure 13
PERCENTAGE OF LAND AREA IN RESOURCE CATEGORIES
HOOPA SQUARE AND KLAMATH EXTENSION

Analysis of percentage figure - Hoopa Square.

1.	Mixed Category: most prevalent	39%	32,424 acres
2.	Large stands of conifer existing in "The Square"	22%	18,811 acres
3.	Brush, or "land-condition" categories	28%	23,418 acres
4.	Bare soil, or high erosion potential (10 & 20% CC Classes)	11%	9,322 acres

Analysis of percentage figure - Klamath Extension.

1.	Mixed Category: post prevalent	33%	18,566 acres
2.	Conifer stands	12.3%	6,810 acres
3.	Brush, or land-condition categories	38.7%	21,236 acres
4.	Bare soil, or high erosion potential (10, 20 & 30% classes)	16%	8,878 acres

Cost of the Project

There are certain general observations and cautions that must be made when looking at the costs involved in a demonstration project. Where a certain amount of research must be done to fit even a clearly proven and known technology to a particular user need. Demonstration projects usually do not compare favorably with more tried and true, operational techniques. The thing to remember is that a great many (if not all) present-day "operational" methods of doing any business have replaced still older operational methods which became outdated.

Additionally, when considering the costs for this demonstration project, we must consider the following relevant facts:

--5 major output products were actually created with several copies.
--4 persons were trained in use of the technology.
--after initial planning and training was done, the actual time for extending the classification scheme to the whole study area ranged from instantaneous to 20 seconds.
--this project for this area is repeatable and updateable in subsequent Landsat scenes. The same methods and techniques are now documented and can either utilize the same statistics or very quickly and efficiently get new ones. The training fields are digitized and stored away. They can be re-used.
--The same data tape has been used to create a wildlife habitat (vegetation mosaic) map, all included in the cost.
--The same data tape and U2 photography could be used by many agencies in the same region, by altering the classification scheme
--The U2 flight data provided approximately 80% of field checking and has provided complete aerial photography coverage of a region that lacked recent photography. Along with utilization in this project, it has to date been utilized by over 100 different agencies, organizations and individuals to assist various mapping projects. Primary among the other agencies use has been Land Use and Land Cover Mapping by the California Department of Water

Resources, and finalization, by the U.S. Geological Survey, of various 7½ minute topographic quadrangle sheets needed in northern California.

--The combination of using U2 and Landsat data has, in this project, significantly reduced labor and travel costs customarily incurred in such areas. This combination has significantly contributed to a highly accurate, acre by acre, assessment of the required land cover conditions on the Hoopa Reservation. This is not a gross inventory, but a very much more detailed set of information, than has ever been available.

Cost Evaluation Notes - Refer to Table 3. This cost evaluation is based simply on two major functions: actual Landsat digital image processing, and training.

There are three major areas that we could successfully "track":

(1) salaries
(2) travel
(3) computer access.

<u>Total salaries for all agencies involved were as follows:</u>

FWS	-	$ 3,600.00	
NASA (Arc)	-	15,000.00	
HSU-Grant Staff	-	16,774.00	(NASA Grant NSG 2244)
HSU-Grad Program	-	3,600.00	(McIntire Stennis funds)
Total		$38,974.00	

<u>Total travel for all agencies was:</u>

FWS	-	$ 300.00	
NASA (Arc)	-	700.00	
HSU-Grant Staff	-	2,500.00	(NASA Grant NSG 2244)
HSU-Grad Program	-	1,600.00	(McIntire-Stennis funds)
Total		$ 5,100.00	

<u>Computer Access</u> is based on (1) <u>2 hours and 21 minutes</u> of NASA Central Processing Units (CPU's) at $360.00/hour. This was what was used for the training and analysis in <u>two</u> projects. NASA funds $ 800.00.
And (2) phone hook-up between HSU and NASA (Arc). NSG 2244 funds 2,134.00

$2,934.00

<u>Total Project Costs</u> - $47,008.00

Table 3 - Cost Analysis

	COST		
SOURCE OF FUND	TOTAL PROGRAM	USFWS PROJECT	HSU McINTIRE-STENNIS
NASA	$16,500.00	$ 8,250.00	$ 8,250.00
HSU/NSG-2244	21,408.00	10,704.00	10,704.00
HSU/McINTIRE-STENNIS	5,200.00	-0-	5,200.00
US FISH & WILDLIFE SER.	3,900.00	3,900.00	-0-
TOTALS	$47,008.00	$22,854.00	$24,154.00
COST PER ACRE:			
(a) 139,500 HOOPA SQUARE, KLAMATH STRIP	.163	.163	-0-
(b) 83,975 HOOPA SQUARE	.287	-0-	.287
TOTAL COST PER ACRE	.450	.163	.287

In conclusion, this project has demonstrated that many of the more conventional, present day techniques can be cost effectively enhanced by remote sensing technology. If, for example, the same sort of technique could be used in classifying the whole scene (some 6 million acres) with a 90% + accuracy in classification as developed in the present project (using a process called signature extension), the costs would be reduced to less than .01¢/acre. This whole concept then points up the notion that the more area (and therefore agencies and entities) involved, the lower the costs and the higher the utilization rate.

It also seems reasonable to assume that once past the "settling-in" stage, and when more truly operational procedures with remote sensing technology are in use by agencies and entities, that costs would naturally be reduced.

SUMMARY

Landsat digital data was analyzed using EDITOR software to map land condition and vegetative cover on the Hoopa Valley Indian Reservation in Northern California. Guided clustering was employed to identify the maximum number of spectral classes within the study area.

Land condition was mapped according to percent crown closure of brush (e.g. <10% to >80%) which was correlated to erosion potential. Vegetational communities were aggregated together and identified as either conifer, mixed (conifer, hardwood and brush) or hardwood.

Evaluation of the classification was completed using binomial approximation within a cluster sampling design. The overall mean probability of correct classification for omission and commission was 0.916 and 0.914 respectively.

CONCLUSIONS

1. Landsat MSS data can be processed, using guided clustering techniques, to accurately map land condition and vegetation cover in regions of rugged mountainous terrain.

2. A successful classification requires reliable and adequate ground information, an interactive computer system with clustering capabilities and adequate time to allow for re-training to increase classification accuracy.

3. Guided clustering techniques are essential for developing training statistics containing the maximum number of spectral classes.

4. A successful classification can be accomplished using a remote computer terminal accessed by phone to a central computer.

5. The vegetation complex of the Hoopa Indian Reservation was described as follows:

Conifer Forest	18%
Mixed Forest	36%
Hardwood Forest	2%
Brush - >80% CC	8%
Brush - 60% CC	6%
Brush - 50% CC	7%
Brush - 40% CC	5%
Brush - 30% CC	1%
Brush - 20% CC	7%
Brush - <10% CC	6%
Water	3%
Snow	1%
TOTAL	100%

6. The crown closure land condition categories comprise approximately 40 percent of the Hoopa Valley Indian Reservation. The sparse brush or crown closure categories (<10% to 30% CC) cover 14 percent.

RECOMMENDATIONS FOR FUTURE WORK

(1) Any remote sensing project will benefit greatly by the following:

(a) Having an in-house person, trained in remote sensing techniques who already has the required discipline background, or

(b) Knowledge of how to find, and deal knowledgeably with, contractors who have remote sensing expertise.

(c) Begin with a small test area to get a good idea of what is involved, then move towards the larger task.

(d) Consider many options. Know who to turn to for various, independent options.

(2) An evaluation and challenge of the "repeatability" capabilities of the Landsat System should be made; specifically, redo this same project in 2-5 years to detect changes in the identical categories within the Hoopa Indian Reservation.

(3) Some of these techniques should be employed by the Trinity River Task Force agencies in their overall design of the 20-year management plan for the basin management.

(4) A careful economic assessment of a $21 million dollar fishery resource versus a management information tool that, in large regional assessments, can cost as low as .01 per acre.

(5) A careful assessment should be made to determine relationships, if any, between the land condition categories, the growth rate and the cutting rate on the Hoopa Indian Reservation.

(6) Further assessment should be made to determine the relationships, if any, between land-condition categories, existing imminent geologic hazards and current timber management regimes, in order to prepare future management (stocking, replant and harvest) plans for the Reservation.

(7) Further assessment should be made of the direct relationship between the "bare-soil" (<10% CC - 30% CC) land-condition categories and the tributaries which need to be cleared of obstructions or are contributing significant amounts of sediment to important spawning tributaries on the Hoopa Indian Reservation.

GLOSSARY

algorithm - A mathematical formula used to calculate a statistic used to place pixels in various categories.

anadromous fish - Several species of fish that live their life at sea and return to fresh water to reproduce.

atmospheric scattering - Light scattered by the atmosphere which causes a near-equal increase in brightness for all pixels, usually greater in Band 4.

bad data lines - Scan lines containing no data.

band - A wavelength interval in the electromagnetic spectrum. Landsat bands are numbered 4, 5, 6, 7. Often computer analysts number them as channels 1, 2, 3, 4.

bit - In digital computer terminology, this is a binary digit that is an exponent of the base of 2.

byte - A group of eight bits of digital data.

calibration file - A collection of points common to a map base and the Landsat image used to 'fit' the Landsat data to the map.

categorized data - Raw data that has been placed into a category.

channels - Wavelength intervals of light energy received by a remote sensing system. See band.

classes - Categories that spectral responses are placed into.

classification - The process of assigning individual pixels of a multi-spectral image to categories, generally on the basis of spectral-reflectance characteristics.

clustering - The process of mathematically assigning similar spectral signatures to classes or categories.

control points - Geographical locations that the Landsat image is corrected or aligned to.

C.R.T. - Cathode ray tube.

dicomed - A pseudo-color photographic reproduction of classified Landsat data.

digitization - The process of converting an image recorded originally on photographic material into a numerical format.

EDITOR software - An interactive computer program that analyses Landsat digital data using guided clustering procedures.

Euclidian minimum distance - A statistical decision rule used by the cluster analysis routine to assign pixels to various categories.

Gaussian maximum likelihood classifier - A statistical decision rule used in conjunction with known training sites to assign pixels to various categories.

ground truth - Data that is collected in the field, on-the-ground inspection.

IDIMS - Hardware developed by ESL Corporation that will classify and interactively color Landsat data.

ILLIAC IV - A parallel processing computer capable of very fast processing speeds. This system is not interactive.

interactive processing - The method of data processing in which the operator views preliminary results and can alter the instructions to the computer to achieve optimum results.

infrared - The infrared region of the electromagnetic spectrum that includes wavelengths from 0.7 m to 1 mm.

Landsat - An unmanned earth-orbiting NASA satellite that transmits multispectral images in the 0.4 to 1.1 m region to earth receiv-stations (formerly called ERTS).

line printer map - A digital computer printout. This can represent gray level, raw or categorized data.

MSS - multispectral scanner system of Landsat that acquires images at four wavelength bands in the visible and reflected IR regions.

management units - Arbitrarily selected subsections of the Hoopa Valley Indian Reservation that correspond with existing cut-block compartments. This facilitated summaries of acres and hectares per area.

non-systematic errors - Variations in spacecraft attitude, velocity and altitude.

packing - The process of taking spectrally similar data from geographically divergent training areas and merging them into one category.

picture element - In a digitized image this is the area on the ground represented by each digital value.

pixel - A contraction of picture element.

pool and merge - The process of putting spectral classes together or deleting to create a final statistic file.

radiometric striping - The striped effect in the image caused by an abnormal increase in the brightness of every sixth scan line.

raw data - Landsat spectral data that has not been classified or enhanced.

separability matrix - A table of separability statistics indicating the statistical separation of defined spectral categories in spectral space.

Signature - A characteristic, or combination of characteristics, by which a material or an object may be identified on an image or photograph.

space craft attitude - The angular orientation with respect to a geographic reference system.

spectral reflectance - The reflectance of electromagnetic energy at specified wavelength intervals.

supervised classification - A technique that uses independent information to define training data that are used for classification.

systematic errors - Geometric distortions which are constant and can be predicted in advance.

training fields - Areas on the ground that are similar in composition that are used to train the computer.

unsupervised classification - A discriminatory procedure that uses only the statistical properties of the image data as a basis for classification.

* Compiled by Kenneth E. Mayer and Lawrence Fox III with extensive reference to Remote Sensing Principles and Interpretation, Sabins, 1978.

BIBLIOGRAPHY

Anonymous. 1973. Hoopa valley water resources investigation and recommendation for water system development. Winzler and Kelly Consulting Engineers, Eureka, CA. p. 119

Aldrich, R. C., N. X. Norick, and W. S. Greentree. 1975. Land-use classification and forest disturbance monitoring. PSW Forest and Range Experimental Station, Publ. No. 112.

Bernstine, R. 1973. Scene corrections of ERTS sensor data using digital image processing techniques. Proc. NASA Goddard Space Flight Center, Greenbelt, Maryland, NASA SP-351, Vol. 1, p. 1909-1928

Cochran, W. G. 1977. Sampling techniques, 3rd edition. John Wiley and Sons Inc., N. Y., p. 66

Heller, R. C., R. C. Aldrich, et al. 1975. Evaluation of ERTS-1 data for forest and rangeland surveys. PSW Forest and Range Experimental Station, Publ. No. 112., p. 67

Hoffer, R. M. 1975. Natural resource mapping in mountainous terrain by computer analysis of ERTS-1 satellite data. University of Purdue, LARS Research Bull. 919, p. 124

Kesner, W. D. 1977. An economic evaluation of the salmon and steelhead fishery attributable to Klamath National Forest. U.S.D.A. Forest Service, Klamath National Forest. p. 17

Morrison, D. F. 1969. Multivariate statistical methods. McGraw Hill Inc. p. 132

Moyle, P. B. 1976. Inland fisheries of California. Univ. of Calif. Press, Berkeley, Calif. p. 405

Rankel, G. L. 1978. Anadromous fishery resources and resource problems of the Klamath river basin and Hoopa Valley Indian Reservation with a recommended remedial action program. U.S.F.W.S. Internal Publ. Calif. p: 98

Rohde, W. G. 1978. Digital image analysis techniques required for natural resource inventories. U.S.D.I. Geological Survey, EROS Data Center, Sioux Falls, S. D. p. 106

Sabins, F. F. 1978. Remote sensing principles and interpretation. Walt. Freeman Co., San. Fran., p. 405

Soto, J. 1978. Personal communication.

Swain, P. H. and K. S. Fu 1968. The application of nonparametric techniques to crop classification problems. National Electronics Conference Proceeding 24, p. 14-19

Wacker, A. C. and D. A. Landgrebe. 1970. Boundaries in multispectral imagery by clustering. I.E.E.E. Symposium on Adaptive Processes, 9th.

SUMMARY OF GRADUATE THESIS IN PROGRESS:

"EVALUATING DEER HABITAT ON THE HOOPA VALLEY INDIAN RESERVATION, NORTHWESTERN CALIFORNIA USING LANDSAT DIGITAL DATA"

BY

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SUMMARY BY

KAMILA PLESMID, PROJECT ASSOCIATE
FOR NSG 2244 FINAL REPORT

MAY 31, 1979

EDITOR'S NOTE

This summary was made from a rough draft of Jeffrey A. Soto's graduate thesis in Forestry, Humboldt State University, Arcata, California. The thesis work was a result of the activities of NASA Grant 2244 at Humboldt State University and, therefore, needed to be included in the grant's Final Report. With Mr. Soto's permission, I have shortened the thesis considerably so that only the main points appear in this report.

The summary contains a brief statement of why and how the research was conducted, includes the final products that were generated from the Landsat digital data, and presents the conclusions that J. A. Soto came to as a result of his work. The summary also contains a detailed description of how change detection was accomplished, using two Landsat scenes of the same area, 4 years apart.

This summary, however, does not contain tabular data that accompanies each of the final map products nor does it contain graphic material and tables that will be included in the Methods and Materials section of the completed thesis. There may also be some discrepancies between my interpretation of the text and what the author actually intended. Any such problems will obviously be set to right in the final graduate thesis.

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INTRODUCTION

In January, 1977, the National Aeronautics and Space Administration (NASA) initiated a nationwide technology transfer program· the Regional Applications Program (RAP). This new program was designed to ensure maximum regional access to the technology of remote sensing. Three regional centers including one at NASA Ames Research Center, Moffett Field, California, were selected to set up various mechanisms to solve the problem of transferring remote sensing technology to local and state entities.

In June, 1977, NASA awarded a substantial grant to Humboldt State University through the Humboldt State University Foundation to "Develop and Demonstrate an Institutional Mechanism for Transferring Remote Sensing Technology to 14 Western States, using Northern California as a test site."

As part of that grant effort, a Landsat Demonstration Project was initiated with the U.S. Fish and Wildlife Service. The project was designed to inventory watershed conditions on the Hoopa Valley Indian Reservation and the Klamath River Extension as one method of analyzing the decline of anadromous fish populations in that area. This inventory emphasized barren or other erodable land associated with timber harvest operations, erosion rates, and in-stream habitat.

Because the potential existed for a more thorough use of the Landsat data, Dr. Lawrence Fox, an instructor in remote sensing and forestry at Humboldt State University and technical coordinator for the U.S. Fish and Wildlife project, proposed that a graduate research project in forestry accompany the Fish and Wildlife Service proposal. This research would be confined to the "Hoopa Square" portion of the Hoopa Valley Indian Reservation and would complement the inventory efforts of the Fish and Wildlife Service.

Specifically, the research work would be in three phases. Phase I was to develop a general land cover classification for the reservation. In this first classification, the ecosystem would be mapped in terms of plant communities and group states of plant succession. This plant succession would be based on species composition, character or indicator species, and vegetation structure or physiognomy. Phase II was to map the early successional stages of vegetation in terms of browsing quality for the Columbian black-tailed deer population on and near the Hoopa Valley Indian Reservation. And Phase III was to detect changes in the vegetation cover using digital data from two Landsat scenes, one August 28, 1973, and the other April 12, 1977. The April 12th Landsat scene was the data used for the U.S. Fish and Wildlife inventory.

This graduate research was funded, in part, by the McIntire Stennis Forestry Foundation in Washington, D.C., with matching funds provided by the Department of Forestry, Humboldt State University. Training in computer processing of Landsat digital data and other technical support was furnished by the NASA Remote Sensing and Technology Transfer Project at Humboldt State University, in conjunction with the Western Regional Applications Program at NASA Ames Research Center, Moffett Field, California. This training for graduate student, Jeffrey Soto, took place at the same time as training was conducted for Kenneth Mayer, the U.S. Fish and Wildlife employee. Both men were also given technical support from the U.S. Geological Survey's Geography Program at NASA Ames Research Center.

STUDY AREA

Location

The Hoopa Indian Reservation, commonly referred to as the Hoopa Square, was founded on April 8, 1864, and officially established by President Grant's Executive Order on June 23, 1876. The Hoopa Indian Reservation approximates a square 12 by 12 miles in size and is located in northeastern Humboldt County, California. The geographic coordinates are as follows:

northwest corner - 41°04.49'N, 123° 48.79'W
southwest corner - 40°59.47'N, 123° 44.96'W
southeast corner - 41°02.92'N, 123° 32.13'W
northeast corner - 41°12.50'N, 123° 35.51'W.

This geographic location lies within Path 49 and Row 31 scene of Landsat data. On an image of this data, the study area is easily identified by the large bend in the Trinity River which is surrounded by pasture land in the Hoopa Valley. The Trinity River runs through the center of the Hoopa Valley Indian Reservation on its way to meeting the Klamath River at the northern boundary of the reservation.

Background for Phase II - Deer Habitat Study

The Hoopa Indians have always hunted deer of either sex, and continue to do so today. The hunting privileges are limited to the Reservation land, where California hunting and fishing regulations do not apply. Hunting is restricted to tribal members only, but there is no season and no limit. Due to tribal customs, does are rarely killed between February and June. Migrating deer that move into the Reservation are harvested by the Hoopas. This hunting removal of migrating deer affects deer population in a considerable area outside of the Reservation (mostly to the east). The removal of deer of either sex produces desirable results within the Hoopa Square as follows: (1) a sustained harvest of deer each year; (2) no record of deer starvation or disease in the herd, (3) no known winter range problems; and (4) little or no problem of deer browsing seedling trees in regrowth areas.

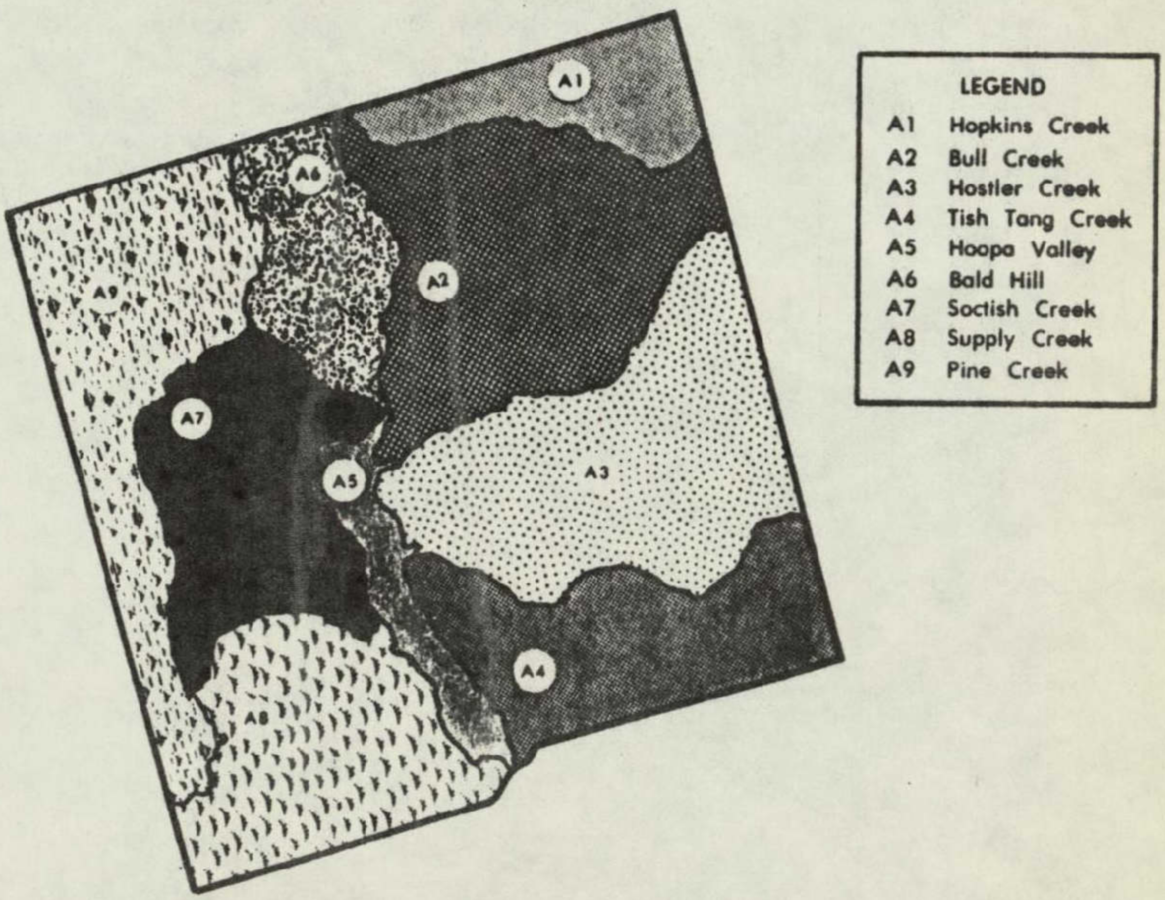
This unique situation existing on the study area stimulated the research which led to the eventual wildlife habitat classification. The critical factor influencing deer population on the Reservation is food. It is assumed that the other factors, water and cover, are readily available to the Columbian Black-tailed deer. The cover is continually enhanced by logging practices that create edge effect while the Hoopa Square is rippled with rivers, streams, and natural springs which provide water all year for wildlife.

Management Units

The Hoopa Indian Reservation was divided into nine management units ranging in size from 3,321 acres to 15,487 acres. (Figure 1.) In general, the inner boundaries of the units correspond to either ridge lines or stream channels. However, the Hoopa Valley Management Unit system was developed to correlate to the rural residential area on the Reservation. These management units directly relate to existing cutting block units used by the Bureau of Indian Affairs foresters. The advantage of developing the management units is that summary tables can be generated not only for the entire study area, but also for chosen subdivisions of the area.

Figure 1

MANAGEMENT UNITS OF THE HOOPA VALLEY RESERVATION



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Step 2. Computer System

The computer system employed was the Interactive Digital Image Manipulation System (IDIMS), developed by ESL, Inc. The system is comprised of several interactive terminals with video display and a COMTAL CRT which is capable of displaying false color composite images, gray scales, and pseudo colored gray levels.

Step 3. Creation of Images

The classified images of the August 28, 1973 Landsat scene and the April 12, 1977 scene were placed on the video screen of the IDIMS image processing system. A control point was found on each image. The coordinates of the control points were found in each image reference system and the offset was determined. The images were then shifted by the offset amount so the control points overlayed. The alignment of the overlayed images was excellent. Two matching windows (subsets) were clipped from the 1977 and 1973 raw data images using the coordinates obtained. The two images created were 250 x 250 pixels in size. When overlaying the two images, it was assumed that each image was correctly rotated to north and geometrically corrected. This assumption may not hold for very large areas where pixel by pixel matchups may be impossible.

The creation of the combined 1973 and 1977 data set was accomplished by combining the two images into one four-band image as follows:

combined channel 1 (Band 5, 1973)
combined channel 2 (Band 7, 1973)
combined channel 3 (Band 5, 1977)
combined channel 4 (Band 7, 1977)

Using unsupervised clustering analysis, all of the pixels within the combined window were grouped into 35 classes.

Step 4. Normalization

A normalization process was performed on the clusters to remove atmospheric effects and censor inconsistencies between the two dates. Normalization of the raw data was based on the means of the clustered data. It was noticed that the spectral counts of the 1973 data were consistently higher than those of 1977 data, possibly due to atmospheric effects. A ratio was set up, such that the means in 1977 were ratioed to means in 1973 (i.e., means 1973 divided by means 1977) for each class in both bands. The average ratio was calculated excluding classes that obviously showed radical change.

Once the average ratio was calculated, the 1973 means were multiplied by that constant value to make them comparable to the 1977 means. Then, by plotting the means and comparing both dates, changes in land cover were depicted graphically to assist in the interpretation of the computer clustering.

Step 5. Data Display

Once the classes that changed were recognized, the combined image was again placed on the IDIMS video display. The classes that had been detected as changing were colored material colors. All other non-changing classes were colored in 20 shades of gray. For example, conifer pixels were assigned to the lowest gray scale values or darkest gray colors and bare soil pixels were assigned to the brightest colors. All other non-changing classes were assigned to the appropriate intermediate values of gray.

Step 6. Data Smooth

To eliminate the "salt and pepper" effect of the final classification, the data underwent a smoothing process on IDIMS. The "salt and pepper" effect refers to the fact that single pixels are often classified differently than surrounding pixels. Due to the extreme sensitivity of the Landsat Scanner, an individual pixel may be misclassified or, in the case of detecting change, a single pixel may indicate a different spectral class within an otherwise unchanged area. The smoothing function evaluated each pixel and the nine pixels surrounding it. The computer routine evaluated all nine pixels involved and classified the center pixel the same as the majority of surrounding pixels. Upon completing the smoothing process, the final classification was submitted to the DICOMED operation so that a final product could be generated.

RESULTS AND DISCUSSION

A separate product was developed for each of the three phases of research work. Each product has a unique classification scheme with associated colors. Phase I is a general land cover classification; Phase II delineates deer browsing habitat; while Phase III relates to vegetation that has undergone a recent (within four years) spectral change. Each map product represents the final classification of all spectral information applicable to the Hoopa Square, for the dates analyzed.

It should be noted that Phase II developed out of Phase I. The deer habitat was determined after the initial land cover classification was completed.

Phase I

The general land cover map for this project was classified similarly to the standard land use and cover classification developed by the U.S. Geological Survey (Anderson, et al, 1976). In the general land use classification on the Hoopa Square, 33 unique spectral classes were grouped into eleven land cover types. Nine of the eleven broad land cover types represent resource types related to vegetation. The other two types describe the water resource on the reservation. (Figure 2.)

A criteria for grouping spectral classes into larger resource types was the relationship of species composition and ecological trends to plant succession. Using this criteria, spectral classes that represented various stages of natural plant growth could be combined into the same general land cover type.

For example, three distinct spectral classes of Tan oak were obtained in the first analysis of the data; however, these were not different types of Tan oak, only Tan oak in different stages of growth. These three classes, then, were all included in the more general category of evergreen hardwood, Class 5.

This type of class combination based on natural plant succession was used throughout the final analysis and classification. What follows are descriptions of each of the eleven general land cover classes and an indication of where they are located within the Hoopa Square. For easy location, BIA management units have been cited and readers should refer to Figure I, page 4.

Class 1 represents pasture land and is color-coded bluish-gray. Approximately 80 per cent of this land cover type lies within the Hoopa Valley Management Unit A5. Some of the pasture land is irrigated and sustains cultivated oats and alfalfa fields. The non-irrigated pasture is a disturbed weed patch. A variety of grass and forb species also occur naturally in this land cover type.

Class 2 is very similar to the mixed rangeland cover type described by the U.S. Geological Survey, and is color-coded dark brown. It includes natural prairies; an early stage of regrowth dominated by rose, grass and fern and a naturally occurring berry, grass and forb cover type. A large homogeneous area of this cover type lies on the boundary between the Bald Hills and Scotish Creek management units, A6 and A7.

Class 3, colored a red-brown, represents a bare soil land cover type and the first stage of of vegetation regrowth on cutover areas. This class ranges from bare ground to a sparse ground cover of grass or young brush sprouts. The class is found mainly in the Hostler Creek unit, A3, where extensive forest harvest has occurred over the past two years.

Class 4 cover category, colored medium brown, resulted from combining various stages of vegetative regrowth. This regrowth class describes all levels of vegetation on recently harvested land, ranging from a low grass, forbs, and shrub cover on a two-year-old clearcut to predominately brush cover on a ten-year-old cut. This class is found over the entire square, especially in the Hostler Creek and Supply Creek management units where extensive logging has occurred, A3 and A8.

The fifth general land cover type is labeled nondeciduous or evergreen hardwood and is shown by a gold color. This vegetative type is predominately composed of Tan oak. Large stands of Tan oak are found in the Bull Creek management block, A2, ranging from very young pure stands to mature stands where 80 per cent or more of the canopy is dominated by this evergreen hardwood.

Class 6, deciduous hardwood, is colored a light yellow. This cover type is found uniformly throughout the study area at elevations less than 1500 feet. The two dominant trees are black oak and white oak. There are also madrone, big leaf maple, and an occasional Douglas fir or Incense fir in this class.

Class 7 is designated as a mixed conifer type and is colored bright green. The type ranges from 40% hardwood/60% conifer to 60% hardwood/40% conifer. In all the hardwood/conifer mixtures, the major conifer component is Douglas fir while the hardwoods are Tan oak and big leaf maple with some madrone.

Class 8 is another mixed conifer cover type; however, the ratio of conifer to hardwood is 70% to 30%. This class is colored medium green. In this class the conifers are generally taller with larger DBH measurements than the true mixed category so that the class is better labeled as a dominant conifer cover type. The same species of hardwoods exist in this class as in Class 7 although the total canopy cover is less. Both Class 7 and 8 are common to the management units east of the Trinity River, A1, A2, A3, A4, probably due to the higher elevations of the mountains in that area.

Class 9 is labeled as a pure conifer type, and is colored olive green. These pure Douglas fir stands are quite dense, with trees varying in height from 30 to 60 feet. Little light penetrates through the canopy, thus little or no understory vegetation exists. The majority of pixels in this land cover type lie within the Pine Creek management unit, A9. They are scattered over this area in relatively small homogeneous pockets, ranging from 3 to 15 pixel areas.

The two remaining classes represent water on the reservation. Snow is designated by a dark gray color and is found primarily in the south corner of the Hostler Creek management unit, A3. Water is colored blue and delineates the course of the Trinity River through the Reservation. In most instances, tributaries flowing into the Trinity were not distinguishable on the Landsat data.

Key - Figure 2

LAND COVER CLASSIFICATION

J. Soto - HSU Project

INFORMATION CLASS	COLOR
1. Pasture Land	Medium Gray
2. Mixed Rangeland	Dark Brown
3. Bare Soil	Red
4. Early Succession (Brush)	Medium Brown
5. Evergreen Hardwood	Gold
6. Deciduous Hardwood	Light Green
7. Mixed Forest	Medium Green
8. Dominant Conifer	Dark Green
9. Pure-Conifer	Black
10. Snow	Dark Gray
11. Water	Blue

Phase II - Deer Habitat Classification

The Deer Habitat map relates vegetation to browsing potential for the Columbian Black-tailed deer. This classification resembles the general land cover classification with respect to the late successional vegetation cover. However, the early plant successional stages are ranked in terms of the quality of browsing habitat for the local deer population. Per cent cover and species composition of the vegetation were used as an indication of habitat quality. Vegetation structure--the size and age of palatable browse species--was also used as an indication of habitat suitability. Consequently, a given habitat may be suitable for the Black-tailed deer but offer varying degrees of quality. This classification shows seven degrees of wildlife quality on the Hoopa Indian Reservation, and six classes with little or no browsing potential.

All types of land cover that had little or no browsing potential for the deer were classified the same as in the general land covermap. These classes are pure conifer, dominant conifer, mixed conifer, irrigated pasture, water, and snow. The color scheme for these classes was altered slightly from the general land cover map so that the deer habitat types could be highlighted. The three dominated classes were color-coded in shades of green, while pasture land was shown medium gray. Water pixels were colored blue, and snow was again shown in a dark gray color.

The deciduous hardwood and evergreen hardwood cover types of the general land cover classification have some potential browsing habitat for deer. The extensive herb layer of the deciduous forest provides limited amounts of grass and forbs, taken by deer in late fall, winter and early spring. Preferred brush species (i.e., Ceanothus and Baccharis), frequently occur in the canopy openings of the deciduous hardwood cover type, while the evergreen hardwood forest provides another source of food, the acorns from Tan oak trees. Acorns have proved to be a valuable source of protein for deer during late fall and early winter months. On the Deer Habitat Classification, the evergreen hardwood forest is color-coded light green and the deciduous forest, generally found on south and west facing slopes, is color-coded gold.

The early successional stages of vegetation are represented by shades of brown and red. Regrowth types together with the mixed rangeland type were ranked according to the quality of deer browse habitat. Preferred brush species, percentage cover, and vegetation structure including evidence of hedging were the parameters considered to rank regrowth areas.

The ideal habitat occurs on 4-7-year-old clearcuts, represented by regrowth category #3, a red color. The following preferred browse species, Ceanothus intergerrimus and thyrsiflouis, Hoccinum ovatum and parvifoluim, Baccharis pilularis, and Arctostaphylos sps., comprise the vegetation in this category. The vegetation associated with this type is growing between 1.0 to 4.5 feet above the ground and covers 80 to 100 per cent of the total ground area.

Key - Figure 3

DEER HABITAT CLASSIFICATION

J. Soto - HSU Project

INFORMATION CLASS	COLOR	BROWSING POTENTIAL
Regrowth #1 - Early	Red-Brown	Low
Regrowth #2 - 2-4 Year Cuts	Dark Brown	Medium
Regrowth #3 - 4-7 Year Cuts	Red (Rust)	High
Regrowth #4 - Late	Light Brown	Low
Mixed Rangeland	Medium Brown	Medium
Evergreen Hardwood	Light Green	Very Low
Deciduous Hardwood	Gold	Very Low
Mixed Forest	Medium Green	Little or No
Dominant Conifer	Dark Green	Little or No
Pure Conifer	Black	Little or No
Pasture Land	Medium Gray	Little or No
Snow	Dark Gray	Little or No
Water	Blue	Little or No

The other regrowth classes were ranked in the same fashion. Regrowth category #2, colored dark brown, represents the second most ideal or medium browsing habitat potential. This type has less total ground covered by vegetation and only some of the preferred brush species are present. It generally occurs on 2-4-year-old clearcuts.

Regrowth areas ranked as having low potential for browsing habitat are the very early stages of revegetation on cutover land or the later stages of regrowth. Regrowth Class 1, color-coded red-brown, represents early plant successional stages. It has grass, young brush, and forbs. The later stage of regrowth, occurring on harvested land over eight years old, was also ranked as having low browsing potential. This cover type is colored light brown and represents brush type vegetation too tall to be taken by the black-tailed deer.

The only other early successional stage that was incorporated into the wildlife habitat classification is the mixed rangeland type. It is colored medium brown and was ranked as medium browsing potential. The grass forb and berry species provide sufficient forage required by deer during early spring months.

Phase III - Change Detection Classification

Changes in land cover types were detected by analyzing the multi-date spectral information from August, 1973 and from April, 1977. By graphically comparing the mean counts of MSS Bands 5 and 7, changes were discovered when the two lines, representing reflectance trends, intersected. Out of the 35 unsupervised classes, eight showed some degree of change over the four-year period.

Classes 20 and 33 represent clear cut areas. Class 33, colored yellow, is highly correlated with 2 to 4-year-old clear cuts, while class 20, colored rust, represents vegetation cover of a less recent clear cut. Light green is the color representing irrigated pasture land or class 34, and dark green shows the grass berry vegetation type found only in the Hoopa Valley and on Bull Hill. Class 15, color-coded light blue, represents either urban areas or dry gravel Water, class 2, did not show change; however, it is colored blue to help reference the other classes on the square. The species composition and per cent total vegetation cover for these cover types were discussed in the general land cover section, pages 8 and 9.

The three cover types not previously discussed which showed change over the four-year period are cover types altered either by mechanical brush raking techniques or with herbicide application.

Brush raking practices on the reservation began in 1972 and most were accomplished during the years 1973 to 1977. Removal of brush was done mechanically with a caterpillar tractor and a brush blade. Brush raking is performed on cutover areas after high lead logging. It is done when the bare mineral soil has not been exposed or sufficiently scarified for a conifer seed bed. If the terrain and soil permit, brush raking is accomplished, avoiding rock outcrops or steep ravines. Class 25, colored violet, represents brush raking on logged areas.

Brush raking practices have also been performed on nonlogged areas. The management goal of this practice was to convert hardwood cover types to conifer cover types. Class 30, color-coded peach, represents vegetation that was brush raked on nonlogged areas. These nonlogged areas were of the deciduous hardwood type and were changed to a brushland vegetation complex. The canopy is scattered with an occasional Black oak or madrone. The shrub layer is predominately composed of Ceanothus at about 50%, with Arctastaphylas, Corylus, Baccharis, Rubus, young Black oak, madrone, and a few Douglas fir saplings comprising the other 50% of vegetation cover. The herb layer supports the species Madia, Vicia, Aira, Cynosurus, Gilia, Cirsium, Lupinus, Scutellaria, Wyethia, and Brodiaca. Brush raked vegetation and logged areas include most of the above species in addition to Cornus and Castenopsis in the shrub layer and Volpia, Vancouveria, Pteridrum, Fesque, and Bromes in the herb and grass layer.

Class 10, color-coded brown, represents vegetation cover that has been sprayed with herbicide. The species associated with the canopy are: Salix, Alnus, Viccinium, Fraxinus, Arbutes, Cornus, Acer, Arctostaphylos, Ceanothus, Castanopsis, and Rubus, with Lithocarpus densiflora, Arbutes menziesii, and Pseudotsuga menziesii accounting for 50% of canopy cover. The herb layer was limited in species composition to bracken fern, poison oak, and a few young brush types of those already mentioned.

Most of the change detected from the comparison of multi-date spectral data related to management policies of the Reservation.

Key - Figure 4

CHANGE DETECTION

J. Soto - HSU Project

INFORMATION CLASS (FROM 35 UNSUPERVISED CLASSES)	COLOR
Class 2 - Water	Dark Blue
Class 15 - Urban or Gravel	Light Blue
Class 33 - Recent Logging (1-4 Years Old)	Yellow
Class 20 - Past Logging (still changing)	Rust
Class 34 - Pasture	Light Green
Class - Grass - Berry Type	Dark Green
Class 30 - Brush Raked (Nonlogged)	Peach
Class 25 - Brush Raked (Logged)	Violet
Class 10 - Sprayed	Brown

CONCLUSIONS

The research on the Hoopa Valley Indian Reservation indicates that the geographical extent of vegetation communities as measured from Landsat can provide useful information for the land manager as well as the ecologist. By examining vegetation types in terms of successional trends and deer habitat browsing potential, a resource mosaic of the Reservation could be defined.

The most significant results of this research are:

1. The computer can be successfully "trained" to recognize both broad land cover types and specific details indicating deer forage conditions.

2. Good statistical separation of the general land cover types and the deer habitat types can be achieved even where minimal class separation exists.

3. The use of multi-date imagery provides pertinent information about the dynamic properties of the ecosystem, both in terms of monitoring plant succession and in monitoring the effect of land management practices in the environment.

Approximately ninety percent accuracy overall was achieved in the final classifications. In part, this was due to precise ground data about species composition, percent cover, and vegetation structures, and to the use of high altitude U-2 color infrared photography that provided both large area coverage as well as high ground resolution. The accuracy was further improved by the use of the advanced computer software, EDITOR, which allows for a thorough interactive multivarient analysis of the Landsat digital data.

By analyzing the information generated from the three final map products, it is possible to determine all potential deer forage habitat on the Hoopa Valley Indian Reservation. In the General Land Cover map, all regrowth areas important to deer browsing and other early successional stages of vegetation were grouped into two broad categories: Class 3, bare soil, and Class 4, early successsion (brush). The Deer Habitat map further delineates this information and ranks these early successional stages in terms of browsing quality potential for deer found on the Reservation. The Change Detection map further refines the deer habitat potential information by keying out areas that have been brush raked on logged and unlogged areas, in addition to recently harvested areas. A combination of the change detection product with the deer habitat map can then pinpoint all areas of high browsing potential for the Columbian black-tailed deer population.

"SUMMARY OF YUROK PHOTO INTERPRETATION CLASS"

by Jeff Soto

At the initial class meeting on January 24, 1978, I gave a slide presentation while discussing the basic theory behind photo interpretation and remote sensing. The idea was to show the Yurok people the various levels at which the earth could be observed from the air and the types of photographic information available to them. Although viewing the land from the air was a new concept, the interest level during the class was high and the material was enthusiastically received.

In the subsequent class meetings I first presented standard low altitude aerial photos of an area unfamiliar to the Yuroks, and asked them to identify various feather-like structures - roads, rivers, and the redwoods. Thse photos and pocket stereoscopes were supplied by Humboldt State University Forestry Department. Then the class looked at photos of their reservation land taken in 1974 by the Bureau of Indian Affairs (BIA). For the next four weeks the class learned basic photo interpretation skills. The elements of photographic interpretation were discussed, i.e., size, shape, texture and tone, as well as various techniques for extracting information from photos.

Some general points of interest taught were:

1) Methods for orienting a stereo pair beneath the stereoscope,

2) methods for systematically searching the area encompassed by a stereo pair,

3) methods for avoiding duplication or omission in interpretation of area common to two or more pairs,

4) methods for handling a large number of photos in an orderly manner during the photo interpretation process, and

5) methods for ground checking.

Also, the idea of convergence of evidence was presented in the process of combining all pertinent photographic information with non-photographic information (cartographic, ground truth).

In addition, time was spent discussing the attributes of the electromagnetic energy spectrums and the theory behing reflectance curves.

At this point, the class was able to work at the primary objective of the weekly workshops. The plan was to locate the dwellings and roadways on the photos and transfer this information accurately to a mylar base map. This base map, supplied by the Northern California Remote Sensing Project showed land ownership and was blown up to match the scale of the BIA low altitude photography for easy transposing.

Over the remainder of the class, this objective was successfully accomplished and presently the base map of the Klamath extension is being used by the Yuroks in conjunction with the Census Bureau to help update the Census Information of the Reservation. Along with a base map, a key was developed for it, and a tabular list by drainage of all the people living on the reservation was compiled.

YUROK INDIANS
PHOTO INTERPRETATION CLASS

A six-week photo interpretation class will be presented to a group of Yurok Indians on the reservation. The class is designed to introduce remote sensing technology to the Indian and begin to train them at basic photo interpretation skills. The technical training will be provided by the Humboldt State Remote Sensing and Technology Transfer Project and be taught by Jeff Soto, a member of the project.

The eventual outcome of the course will be an in-place-map to be used by the Yurok Indians and the Census Bureau. This map will show the road systems on the Klamath extension. The Klamath extension is a 45 mile length of land that runs one mile either side of the Klamath River from Weitchpec to the mouth. The improved map of the road network will ultimately be used by the Census Bureau to conduct a population count.

In addition to teaching photo interpretation skills, the second half of the course will focus on the area of remote sensing. The history of remote sensing as well as potential for current and future applications using remote sensing will be discussed.

YUROK INDIANS PHOTO INTERPRETATION CLASS

Course Outline

I. First week.

A. Introduction to photo interpretation.
B. Slide show.
C. Photo interpretation lab exercise designed to show stereoscopic viewing on low altitude photographs.

II. Second week.

A. A detailed discussion on light, reflectance, and cameras and film/filter combination.
B. A lab exercise which involves photo interpretation using size, shape, tone, and characteristics to identify ofjects.
C. General discussion of class projects.

III. Third week.

A. Work on class project. Update roads on the Klamath extension for the Census Bureau.
B. Begin to precisely map the roads system on quad maps.

IV. Fourth week.

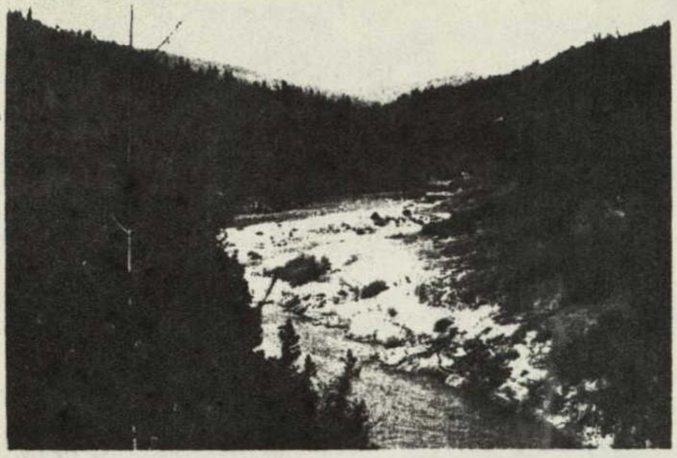
A. Introduction to remote sensing.
B. Slide show demonstrating uses of remote sensing technology.

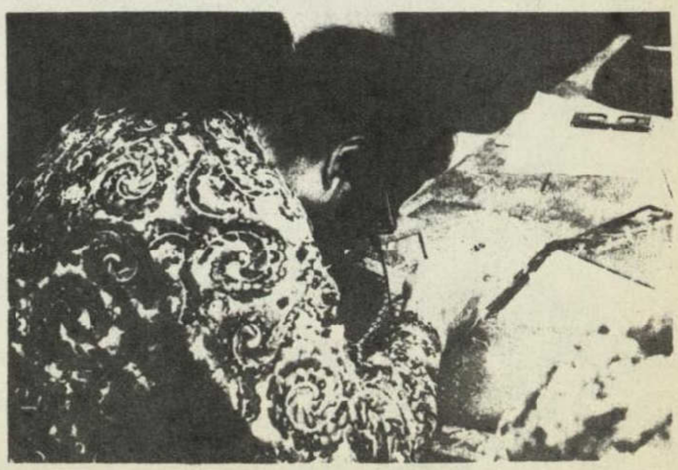
V. Fifth week.

A. Further discussion on remote sensing, i.e. data, types of data available using high altitude photography and satellite imagery.
B. Guest lecture from a remote sensing specialist.

VI. Sixth week.

A. Discussion of potential remote sensing projects involving the Yurok Indians.
B. Discussion of how Humboldt Remote Sensing Grant and proposed Yurok projects.





"PERSONAL EVALUATION OF YUROK AIR PHOTO INTERPRETATION CLASS"

by Jeff Soto

I believe that the photo interpretation class taught out on the Yurok Reservation was highly successful both in terms of the end product generated and the basic photo interpretation skills learned by members of the class.

Several Yurok people are now quite competent photo interpreters and seem genuinely interested in learning more about the Remote Sensing Technology. The final map product has already proved useful to the Census Bureau and to the members of the Yurok community. It is my observation that the map base of the Klamath Extension is constantly being utilized by the Yurok people and hopefully they will continue to update the map as more people and as new road systems enter the scene.

June 10, 1978

February 1, 1978

Jeff Soto
c/o Donna Hankins
Director, NASA Remote
Sensing & Technology
Center for Community Dev.
H.S.U., Arcata, CA.

Re: Yurok Classes

Dear Mr. Soto:

I am writing this letter to let you know that I appreciate the time and effort you are putting into the weekly classes you are giving. After two sessions, I can see the enthusiastic reactions of the Yurok people taking them.

Before the first class, many people were skeptical of any value they might get out of a remote sensing project/training. The first session's slide show captured their interest. The idea of being able to look at the land on which they live from an entirely different perspective was fascinating. I believe that at least some of those taking the class will go on to participate in a project designed to survey the resources of the Klamath River.

I hope you will continue giving these courses. Yuroks of all age and education levels will benefit. Additionally, and other information you might bring relating to remote sensing and resource evaluation possibilities for this area in the future will be greatly appreciated.

Sincerely,

/s/ Murray MacNeill
YRIC Coordinator

Yurok Research
&
Information Center
P.O.Box 366
Hoopa, California
95546

June 9, 1978

Donna Hankins
Center for Community Development
Graves Annex
Humboldt State Univ.
Arcàta, CA. 95521

Dear Ms. Hankins,

This letter is to thank your office for your cooperation in our Extension Map Update Project. Jeff Soto provided invaluable training in aireal photo interpretation which was a great help in transfering roads and houses to our map.

The theory which Jeff taught regarding high altitude remote sensing was a good background for possible future projects. How ever further training would be benefical especially with U-2 and Land Sat. Imagery. As to date, Linda Gillespie, Michael VanGuilder, and others including myself feel very comfortable with the basic photo interpretation knowledge. We are very pleased with the milar blow-up and product aid finder that it has uses other than showing simply the present day roads and dwellings.

The only real criticism of the class relate the materials. There is a need for updated low altitude photographs as well as recent U-2 Imagery. Part of the project, the mapping of the lower Klamath River, was not fully completed due to a lack of color photographs.

I hope that you, Jeff and your staff can get together with us in the near future to celebrate the successful completion of the course and to discuss possible projects. I'll visit you the next time I'm in town. It has been a pleasure working with you.

Sincerely

Murray MacNeill

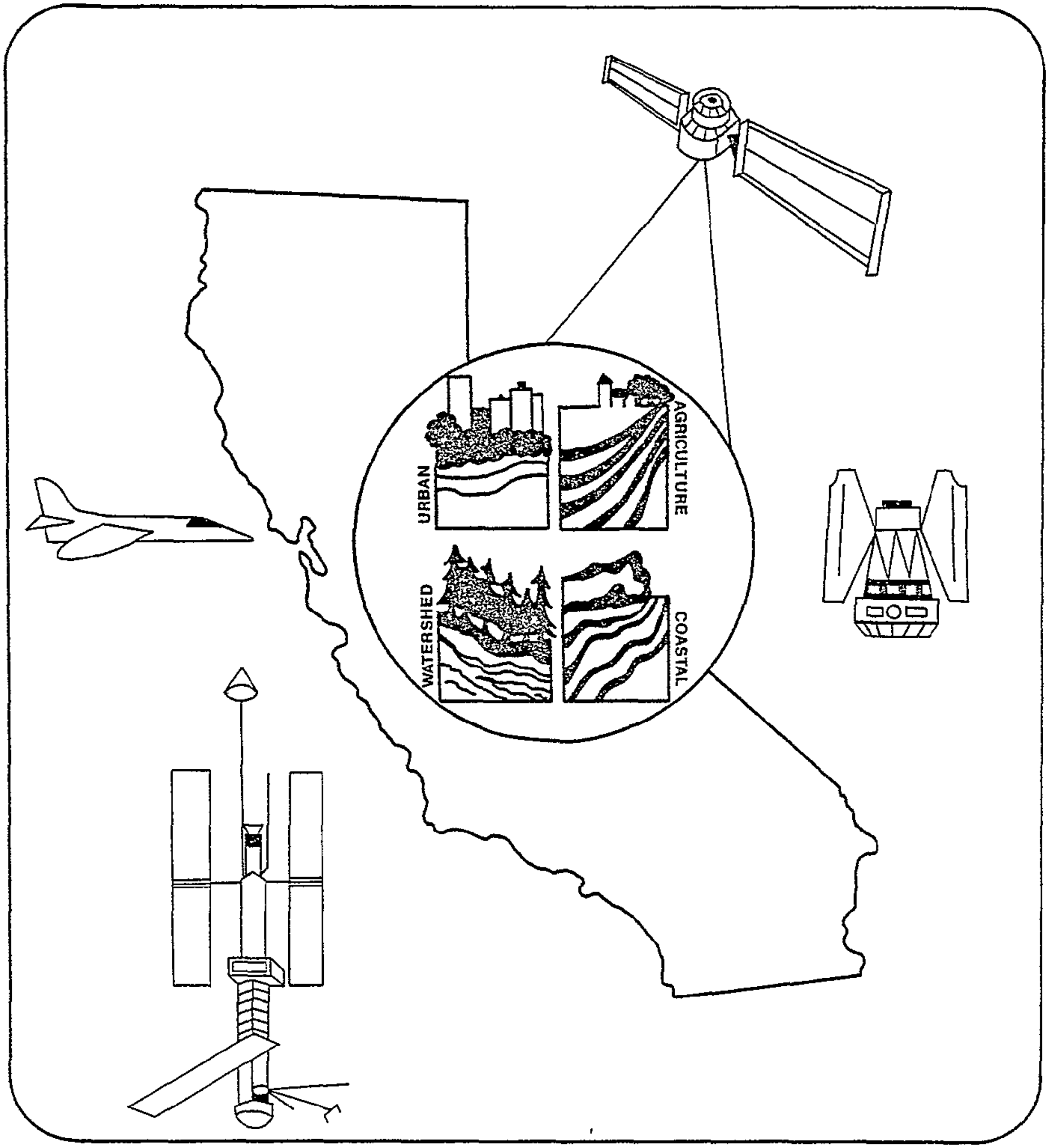
APPENDIX VI

Documentation: Results of Statewide Survey of Remote Sensing Activities in California, "California in Orbit"

CALIFORNIA IN ORBIT

A SURVEY OF STATE REMOTE SENSING ACTIVITIES

1977-1978



IN PARTIAL FULFILLMENT OF NASA GRANT 2244

COMPILED BY DONNA B. HANKINS AND KAMILA PLESMID

HUMBOLDT STATE UNIVERSITY ARCATA CA 95521

PREFACE

This document is a first-of-a-kind attempt to thoroughly survey the status of remote sensing technology transfer in California. The survey was attempted in view of increasing demands for resources data and for "getting the most for the least," while actual use of this cost-saving technology in California remained a rumor. As typical with such a survey of fluctuating phenomena, parts of it have already become dated.

All credit and praise for this report goes to Donna B. Hankins and Kamila Plesmid of the Center for Community Development, Humboldt State University. Any opinions or recommendations in the report are theirs and do not necessarily reflect the views of the EDC or the Office of Planning and Research.

The EDC plans to coordinate annual up-dates of the survey, so do not hesitate to use the "Notice of Change" form at the back of the report to notify us of any corrections that should be made.

Sally Bay Cornwell
Environmental Data Center
Governor's Office of Planning and Research
1400 Tenth Street
Sacramento, California 95814

February 1979

TABLE OF CONTENTS

CALIFORNIA IN ORBIT

Introduction

During late 1976 and early 1977, the National Aeronautics and Space Administration (NASA) initiated a nation-wide activity called the Regional Applications Program (RAP) This new program was designed to ensure maximum regional access to the technology of Remote Sensing, particularly within State and local governments and agencies (but not limited to them)

The program began to take shape in January, 1977, as NASA decision makers selected three NASA lead centers within groupings of State/Federal Regions—one at Goddard Space Flight Center (INTRALAB), Maryland, one at Earth Resources Laboratory (ERL), Sliddell, Louisiana, and one at NASA Ames Research Center (WRAP), Moffett Field, California. Each center began to set up various mechanisms to solve the problem of transferring remote sensing technology to the key state and local agencies within their assigned regions

The technology transfer program selected by NASA Ames Research Center (WRAP) highlighted the need for this survey, CALIFORNIA IN ORBIT

It was soon apparent to both NASA (WRAP) and to various State agencies that California represented a unique technology transfer problem among the 14 western states included in the WRAP region. California, a large and very diverse state physically, also has extremely diverse methods for gathering and analyzing environmental data Private industry, State and Federal agencies, Counties and universities often have their own approaches.

Earlier attempts to incorporate remote sensing into the data gathering systems of the state had met with heavy problems, both political and technical in nature Numerous individuals who were involved in those early efforts still work in California State Agencies and tend to view new efforts with an understandably critical eye

On the more positive side, however, California, as a state, seems well on the way toward accepting aerospace technology as a resource monitoring, assessment and analysis tool Certainly, the climate in Sacramento has been beneficial

FIRST California elected, a colorful, satellite-oriented governor, Jerry Brown, who selected as his space and science advisor, Rusty Schweikart, an ex-astronaut

SECOND Certain legislators in California have received briefings from individuals, agency and university people within their constituency on the applications possible with remote sensing From these briefings and from informational workshops sponsored by the Remote Sensing Task Force of the National Council of State Legislatures (NCSL), California legislators have begun to formulate legislation with this new tool in mind

THIRD Several state and federal agencies within California are using or are making plans to use remote sensing techniques in their implementation of various Federal and State legislative acts and laws

and FOURTH California state agency personnel, along with members of other agencies, universities and the private sector, have formed a Remote Sensing Advisory Council (RSAC) The key charter of the RSAC, among other elements, has been to "enhance and promote use of remote sensing in state agencies and to provide counsel and advice to agencies wishing to have information on remote sensing"

Paralleling the climate in Sacramento have been the remote sensing activities at California colleges and universities National leaders in university research and development and in education in Remote Sensing are located in California, primarily within the University of California and private college system As their programs have grown so have the number of people trained in remote sensing. Many of these graduates have found permanent positions within California agencies, Federal agencies located in California, and in California industry

Perhaps the single most positive action, though, for the acceptance of the technology came early in 1977 The Administration and the California Legislature recognized the need for a state "center" which could coordinate existing environmental data (maps, photography etc), catalog and disseminate information about existing data within state agencies, and coordinate collection, storage and retrieval of new data, including remotely sensed data This center would provide a focal point for formerly fragmented and disassociated Remote Sensing activities

In early 1978, under the auspices of the Office of Planning and Research, the California Environmental Data Center was created, and Mrs Sally Bay Cornwell, formerly director of the NCSL Remote Sensing Task Force, was appointed EDC's director

At the same time that California was growing more receptive to some sort of organized, state-oriented program of remote sensing activities, the director and staff of the Remote Sensing and Technology Transfer Project at Humboldt State University in Northern California were involved in a project to create a *model* for technology transfer within the WRAP (14 western states) Region

In the past year and a half, the project has found that introducing a new technology and transferring it is very akin to the problem of introducing a new product or service to the sales market The first thing needed is an understanding of what products and services are currently available in the same line Then, a coordinated plan can be made for introducing the new item

Therefore, it was decided that a survey of existing Remote Sensing activities in California would be a very useful tool for the broadest range of interests, i e people either already involved, or about to become involved, in using Remote Sensing in their work, legislators at both the state and federal levels, university faculty and students, as well as individuals in private industry

---

Sources of Information

The survey, which began in October 1977, is intended to fill a need that has existed for some time Initially, survey forms (Appendix) were completed during telephone conversations with key individuals involved in remote sensing projects The *NASA Grants Program to Universities* for FY77 was used as a cross reference source, and a computer listing from the Smithsonian Institute's data base provided still other materials for cross-referencing The material from the

Smithsonian also identified projects not funded by NASA, but involving remote sensing. Numerous individuals within universities, agencies and private industry have provided first hand input and are cited either within the survey itself or in the list of selected references These people often provided valuable leads to still other information sources

Early in the survey activities it became apparent that a survey of this kind would be incomplete without looking at projects using all types of satellites, Landsat, communications, and weather satellites It also seemed important to include projects using high altitude aircraft (U-2) data and data from conventional medium altitude aircraft There were far more projects than expected, and most projects used two or more types of remotely sensed data Some used four or *more* kinds of Remote Sensing data Many had computerized data bases as their ultimate goal and planned to incorporate the classified Landsat tapes into the data base.

These developments have led to a far more comprehensive and time-consuming survey than was originally intended We believe that it is probably still not complete, since projects and activities seem to be originating almost daily

Recommendation and Summary

It is a strong recommendation that a system for updating this report be initiated immediately through the California Environmental Data Center (EDC) A form of numbering or identification for *each* new remote sensing activity start-up, along with a brief written review of what is to be done, and the key contact people, could be sent to the EDC for circulation as a way to update this report As projects reach various milestones and final completion dates, reports on the results could also be circulated or reviewed through EDC

One of the significant findings, early in the survey's compilation, was that despite the number of universities, colleges, State, Federal and local agencies, and the private sector involved in Remote Sensing activities, very little cross fertilization or exchange of information was taking place The survey itself has served as an information exchange The survey takers also found that nearly all persons interviewed wished to have an updating mechanism setup upon completion of the survey

The major reasons given for this updating were

potential users of Remote Sensing will have a human resource reference bank who can advise them about remote sensing projects already completed or in progress

results of remote sensing projects will be widely disseminated on a regular basis

new start-up activities can make use of the information and may be able to extend their intended activities by pooling dollars and personnel resources

and users will have more input to future technology that is created if they have access to results of projects and activities other than their own

No attempt was made to analyze the information collected in this document

Collecting and reporting were the major goals of this survey We believe that this survey will provide a strong information base for a wide variety of users, but it will need the "updating mechanism" to assure its continued value Comments, additions or changes in the survey should be directed to

Ms. Kamila Plesmid or
Ms Donna Hankins
REMOTE SENSING II PROJECT
Schmidt House 90
Humboldt State University
Arcata, CA 95521
(707) 826-3112

ACKNOWLEDGEMENTS

I want to thank the many people who have contributed information and guidance in preparing the survey They are legion in number, far too long to list here, but those who are listed as key contacts in the summaries of each section have been major contributors

My warmest thanks go to co-author, Kamila Plesmid, whose great talent lies in assembling, writing, organizing and tending to details All these talents have been utilized in this document

Finally, I want to thank Sally Bay Cornwell, of the California EDC, who has been most encouraging and supportive of this survey

SECTION I — REMOTE SENSING TECHNOLOGY

REMOTE SENSING OVERVIEW

The Technology

Although many devices, including our own senses, are "remote sensors," remote sensing commonly describes the application and interpretation of photography from high altitude aircraft and electronic data from satellites Remote sensing devices use electromagnetic energy in the form of light, heat, and radio waves to detect and measure the earth's characteristics The advantages of gathering data about objects remotely are that the object is usually not disturbed, objects in inaccessible areas can be examined, and a large amount of information over any geographical area can be obtained

Until recently, remote sensing was synonymous with photo interpretation Aerial photographs in the visible portion of the electromagnetic spectrum were (and still are) used for topographic mapping, engineering and environmental studies, and exploration for oil and minerals In the 1950's and 1960's, new technology enabled photographic images to be acquired at other wavelengths—photo infrared, thermal infrared, and radar

Of the three, photo infrared has had the most wide-spread use Compared to black and white or natural color photographs, photo infrared—which is just beyond the visible—provides for a better contrast between features in the scene Photo infrared penetrates haze so that the photograph has a better spatial resolution and contrast, it captures the maximum reflectance from vegetation because plants reflect infrared light And it also provides a heightened distinction between land and water For these reasons, infrared photography has been a mainstay of remote sensing.

Although less widely used, thermal infrared and radar have also added a great deal to the development of remote sensing technology While photographic infrared senses energy that is reflected from objects, thermal infrared detects and records radiated energy, or heat. Since heat radiates from objects day and night, thermal infrared sensors have an advantage over photographic ones Thermal IR is useful over water to study water currents, sea ice, thermal plumes and oil films, and it also detects lava flows, volcanos, coal fires and geothermal areas

Radar differs from both thermal and photographic infrared because radar systems receive and record energy that they have generated themselves Systems such as side-looking airborne radar (SLAR), the most commonly used type in remote sensing, emit a beam of energy and then record the various signals that reflect back from objects or terrain Due to the high penetrability of radar through cloud cover, it functions well day or night Although past military security limited the use of radar, at the present time its applications for earth and ocean investigation are growing

Satellite Remote Sensing

In the 1960's, remote sensing took a jump forward with the development and deployment of manned and unmanned earth satellites Here was a new and expanded vantage point for acquiring imagery of the earth The majority of the manned satellites such as Gemini, Apollo and Skylab, came back with photographs of the earth However, since unmanned satellites could not send back film once they were in space, these satellites had to be equipped with sensing devices other than cameras

Now, as then, sensors aboard these earth-orbiting unmanned satellites scan segments of the earth's surface, reduce them to line patterns "seen" at various light wavelengths, and transmit the images or the images' components to receiving stations on earth.

In 1960, the National Oceanic and Atmospheric Administration (NOAA) launched the first experimental weather satellite, TIROS Since that time, both NOAA and the National Aeronautics and Space Administration (NASA) have put many experimental and operational satellites into orbit so that each day thousands of satellite images are received and stored in a variety of forms—negatives, film loops, and digital data on magnetic tape.

A series of experimental earth resource satellites—Landsats—that NASA has launched are changing the scope of environmental remote sensing Data from Landsat-2 and Landsat-3 (Landsat-1 was shut down in January 1978 after 5½ years of operation) are beamed to earth in computer-compatible form Each scene that the satellite scans is preserved on magnetic tape or 70 mm film so that the image can be reconstructed in photographic form or analyzed in a computer

One advantage that Landsat imagery has over aerial photography is that a single Landsat view can cover a greater area than a hundred aerial photographs Maps produced from the latter frequently take so much time to assemble that they are obsolete by the time they are printed. In addition, large-scale features that can be recognized in Landsat images are sometimes obscured in mosaics made from aerial photography.

Handling Landsat data by computer or "automated image interpretation" makes the information even more valuable. Once the computer has been programmed to correctly identify sample categories of land cover in a scene, it can classify the entire Landsat scene (of 100 nautical miles on a side), identifying all areas that have the same or similar reflectance properties or signatures With this process, large area inventories can be taken, land use maps developed, and resources monitored An important feature of Landsat is its repeated coverage of the earth Between the two satellites, there is the possibility for updating data on any area in the world every nine days

While the Landsat program is still considered an experimental satellite system, weather and communication satellites have been in operational use for many years. Although the majority of the data from remote sensing devices on weather satellites is used for long and short range weather forecasting (70-80%), these operational systems are becoming more versatile They are helping to locate the best ocean shipping routes, seek fishing areas, monitor iceberg movement, assess earth resources, and monitor solar flux

In addition to the remote sensors on board satellites, geostationary operational spacecraft like the GOES series and communication satellites are acting as relay platforms for environmental information sampled on the ground or at sea These "fixed" satellites can also telemeter information from mobile sensors For example, NOAA makes operational use of the GOES satellite to relay information from hurricane hunter aircraft in the south Atlantic to the National Hurricane Center in Miami This information keeps track of a hurricane as it develops

The Applications

Remote sensing is an inventory tool with applications in almost every profession and discipline concerned with the environment For the geographer or cartographer, remote sensing gives a view of the earth never imagined on the ground. New areas are mapped, old areas are better understood

For the forester, remote sensing facilitates harvesting and reforestation plans Foresters have long used low altitude aerial photography to manage timber stands Landsat can help assess an entire forest for long-range planning Weather satellites can also provide valuable fire weather and fire danger information to support on-going fire protection efforts

The geologist uses remote sensing to observe fault systems and locate mineral and fossil fuel deposits that often occur along a fault The broad coverage of the Landsat image helps "lift" a fault line out of the ground features

The agriculturalist judges crop yield or crop damage from aerial photography and Landsat data With satellite systems, there is the potential for swift and frequent crop inventories that are fundamental to accurate crop forecasts

The environmentalist detects oil slicks and the off-shore dumping of waste using high altitude photography and satellite imagery—while the oceanographer studies ocean currents, upwelling areas, and bay and coastal environments from weather satellites.

Remote sensing helps the meteorologist and the hydrologist Meteorological events can be investigated, water resources can be assessed, and flood control techniques can be monitored

Remote sensing, in its many forms, has a use in almost every area of earth resource investigation And, users of satellite data can be just about anyone, so pervasive has the view from space become in our society

California is no exception It seems reasonable to assume that California's reliance on remote sensing tools will continue to grow in a direct response to the state's growing need for more accurate and up-to-date information about its natural resources

REMOTE SENSING IN CALIFORNIA—A Brief History in Water Quality Control
by Gibert Fraga, State Water Resources Control Board

1954 marks the beginning of aerial surveillance activities in California—activities which were to develop into the use of remote sensing tools. In 1954, a small aircraft and a 35mm camera with color slide film were effectively used to study the "signatures" of two prominent pollutants in South San Francisco Bay

Between 1955 and 1963, a series of water supply and pollution surveys were taken using low-flying aircraft and cameras The area of study grew from one or two spots to a belt, extending from Morro Lake to Bishop to Owens Lake, Death Valley and Tecopa-Shoshone.

In 1963, while water pollution control research continued in Sacramento, the Departments of Fish and Game and Conservation began investing in survey aircraft The Dept of Fish and Game included water pollution researchers on their flights to test what was to become "remote sensing" applications At that time there was also a group called the California State Employees Pilots Association Through this group, there was a restructuring to form the first remote sensing council or committee

In 1966, Governor Ronald Reagan urged state employees to link up with private industry to design new methods to help solve California problems Out of "Experiment in Government" came the formation of the International Remote Sensing Institute, and a new energy for serious remote sensing applications at California universities.

However, this new enthusiasm for the technology was short-lived as the political climate for the use of remote sensing changed Consequently, the original group of remote sensing users at the state level "disbanded" In the late 1960's, the work in aerial surveillance and remote sensing was fragmented although heavy aerial survey studies were made from the San Francisco Bay area to the Oregon border during that period

In 1970, interest in the statewide use of aerial surveillance and remote sensing partially revived, and in the following year, "Low Altitude Aerial Surveillance for Water Resources Control", was published But the time was still not right for extensive use of the technology

With the arrival of Jerry Brown, remote sensing applications were finally on the upswing again in California. Governor Brown took a keen interest in the history of water resources remote sensing application in the state, and he encouraged the addition of remote sensing to the training series of the State Water Resources Control Board Finally, in 1977, members of the original remote sensing council got in touch with each other to form another, stronger California Remote Sensing Council

Through Governor Jerry Brown, his Science Advisor, Rusty Schweikart, and the Office of Planning and Research, the Environmental Data Center was formed with goals to include the coordination of remote sensing application in the state (Section V) With the additional development of the NASA Western Regional Applications Program (Section II), technology transfer to California users was also growing at a rapid pace

The key to some of this success seemed to be a realignment of the term "user-driven." Remote sensing technology can't be user-driven in terms of real government units if state people are not aware of the applications or are forbidden to look into them

Although state legislation still does not spell out the use of remote sensing tools, the passage of such bills as AB 452, a statewide assessment of all forest resources, points the way for a greater state involvement in remote sensing

The time finally seems to be right for California to apply the technology when and where it is needed. Remote sensing now has the potential to become the backbone of the state's data collection and analysis efforts

SECTION II — CALIFORNIA REMOTE SENSING ACTIVITES

The National Program

In January 1977, the National Aeronautics and Space Administration (NASA) enlarged the scope of its charter to include a vigorous technology transfer program. The focus of this on-going program is the public sector state and federal agencies and local, state, and tribal governments Three regional application centers across the country have been designated by NASA to work with these groups and demonstrate the applications of the Landsat system

Training agency and government personnel in the technology is the key feature of these Landsat demonstrations. The projects allow the users to decide if remote sensing and Landsat can work for them to solve many of their resource management problems

The technology transfer program is a departure from the approach of the past Instead of merely providing a product to an agency, the applications program takes the user through the steps of product development With this method, there is a good understanding of the technology at the end of a demonstration project and a climate developed within the agency for future applications of remote sensing

At all three regional centers, the committment of resources falls on both sides—NASA's and the users' Depending upon the project, the user agency is expected to furnish travel and release time for those of its personnel being trained in the technology as well as allocating budget monies in some cases NASA provides computer time, trainers, and project coordination

Western Regional Applications Program and California

California is one of fourteen states included in the Western Regional Application Program (WRAP), located at NASA Ames Research Center, Moffett Field, California Dr Dale Lumb is the director of that program, and Ms Susan Norman is WRAP coordinator for California remote sensing activities

Dr Dale Lumb, WRAP Director
Susan Norman, WRAP California Coordinator
Mail Stop 242-4
NASA Ames Research Center
Moffett Field, CA 94035
(415) 965-5897

Since there are already many, diverse remote sensing activities in California, WRAP has sponsored few Landsat demonstrations in the state Instead, the WRAP program has pursued an ASVT (Applications Systems Verification and Transfer) program for California so that the multiple remote sensing activities can be coordinated and so that a lateral transfer of the technology can be encouraged among state, local and federal user agencies

Landsat Demonstration in California under WRAP

At this time, the WRAP program is involved directly in five demonstration projects in California to transfer remote sensing technology

In northern California, WRAP is working with the NASA Remote Sensing Project at Humboldt State University, Arcata, and the U S. Fish and Wildlife Service to map the successive vegetation conditions in clearcut areas and standing forests of the Hoopa Valley Indian Reservation and the Klamath River Extension in Humboldt County This project also has the help of the Research and Analysis team of the U.S. Geological Survey Geography Program.

There is also a project in northern California with the State Water Resources Control Board to use Landsat to estimate the reservoir volume of the Tule Lake Reservoir in Siskiyou County

In central California, a five year study (ASVT) is underway for the California Department of Water Resources to determine the water demand for agriculture in the state The Space Sciences Laboratory at UC Berkeley and the Geography Remote Sensing Unit at UC Santa Barbara are involved in assessing the irrigated lands in the Central Valley of California and in 14 northern counties The project is under the management of Ms. Ethel Bauer, a member of the NASA WRAP program

Another project being coordinated by WRAP in central California is an inventory of hardwood forests for fire impact with the Central Coast Resource Conservation and Development Commission This demonstration was initiated by the Commission and will be located in either San Luis Obispo County or Santa Cruz County.

WRAP is also working with the California Department of Forestry to help them assess and analyze all the resources on California forest land. The project, in response to AB 452, will begin with a vegetation classification of northern California Eventually, CDF will analyze the entire state and develop a system to update the information on a regular basis

For more information on the WRAP program and/or to be placed on the WRAP newsletter mailing list, contact:

Ms. Phoebe Williams
Information Services
Mail Stop 242-4
NASA Ames Research Center
Moffett Field, CA 94035
(415) 965-5897

WEATHER SATELLITE USERS IN CALIFORNIA

The most common users of weather satellite data in California are Weather Service Forecast offices and military and naval bases These facilities use the data operationally, on a day-to-day basis

There are a few other specialized uses of the satellites These programs usually center around an individual weather satellite or a satellite series and have involved a few state agencies, state universities, and private industries in the use of weather satellite data, imagery, or data transmission.

GOES Satellite System Applications

The Geostationary Operational Environmental Satellite (GOES) system provides frequent (every 20 minutes) visible and thermal infrared imagery of the ocean areas adjacent to the United States In addition to imagery, GOES has a Data Collection System which relays data from both stationary and moving sensor platforms on earth.

The National Environmental Satellite Service (NESS) is the principal handler of GOES data on the West Coast. A NESS station is located adjacent to the Weather Service Forecast office in San Francisco (Redwood City).

GOES tap hook-ups in California are:
- Weather Service Forecast offices—San Francisco and Los Angeles
- Moffett Naval Air Station, Moffett Field
- Vandenburg Air Force Base, Lompoc
- Beale Air Force Base, Marysville
- NASA/Ames Research Center, Moffett Field
- Satellite Test Center, Sunnyvale AFS
- Sacramento River Forecast Center

CDF Fire Weather Information System

Since 1976 the California Department of Forestry and NASA have been experimenting with using the GOES satellite as a relay for remotely sensed fire weather data. (The project, which began in 1972, at first used Landsat-1 for its relay)

The current network of 18 remote sensor ground stations is located in Region I of CDF, the coastal forests from San Francisco to the Oregon border Data from the remote sensors is telemetered by GOES to Washington, DC, where it is coded and sent back to California At the Sacramento River Forecast Center, the information is translated into plain language and then made available to CDF ranger stations in Region I

For CDF the experiment has been a success. By Summer 1979, CDF plans to purchase 20 sensing platforms of their own and go "operational" with the system (NASA only provided the ground stations for the experimental phase of the project) CDF also plans to share the cost of a receiver station for the fire weather data with the Department of Water Resources, Snow Survey Branch

Eventually CDF would like a statewide network of ground stations to collect fire weather data. Bill Innes, Senior Meteorologist for CDF, is reponsible for the program

Bill Innes, Senior Meteorologist
CA Department of Forestry
Fire Protection
1416 Ninth Street
Sacramento, CA 95814
(916) 445-9887

DWR Field Snow Survey Project

The Department of Water Resources, Snow Surveys Branch, has been testing a data collection platform, similar to the ones in use by the Department of Forestry, to gather snow pack information from wilderness areas This model is located at the DWR Alpha Mountain Research Site above Wrights Lake in El Dorado County

The small data platform has definite advantages over the larger and more costly ground repeater stations which have been used in the past to relay radio signals from snow sensors. First, the small platforem complies better with the Federal Wilderness Act because it is less obtrusive in the environment Secondly, each platform is independent of any other and transmits its data directly to the GOES satellite GOES relays the data to Washington, DC, where the snow data is handled in the same manner and with the same equipment as the CDF fire weather data

In fiscal year 1978-79, DWR will purchase six data collection platforms and plans to share the cost of a receiver station for the data with the Department of Forestry A receiver station in California will simplify the present data handling and will accelerate the operational use of snow data collection platforms in wilderness areas Ned Peterson and Charles Howard, DWR Snow Surveys Branch, are responsible for this project

Ned Peterson, Snow Surveys Branch
Charles Howard, Snow Surveys Branch
Division of Flood Management
Department of Water Resources
1416 Ninth Street
Sacramento, CA 95814
(916) 445-2196

NOAA 6 Series Satellites Applications

The NOAA 6 series (soon to be renamed TIROS) weather satellites have been providing a wide variety of information about the atmosphere and oceans for many years As part of their sensor package, these satellites provide visual and thermal infrared imagery Thermal infrared sensors have been particularly helpful in acquiring sea surface temperature data and discriminating between snow/ice/clouds and water

Fishing by Satellite

Since 1975, various fishing associations, working with University programs, have been experimenting with thermal infrared imagery data to locate schools of fish These groups are studying the sea surfacr temperature breaks along the West Coast as interpreted from the weather satellite imagery The NOAA 6 series is the primary source of data with back-up information coming from the GOES satellite

Fishing with the help of weather satellite imagery is being researched or undertaken in all of the West Coast states—Alaska, Washington, Oregon and California However, the imagery still plays a very small part in commercial ocean fishing

Major projects in California are

——The Marine Advisory Extension Service, Humboldt State University, Arcata

Fred Jurick, director of the project, has been working with North Coast fishermen to study the relationship between water temperature, as ascertained by satellite imagery, and fish availability The current project focuses on salmon and albacore tuna found in the waters off the northern third of the California coast Depending upon the cloud cover along the coast, Jurick is able to obtain useful imagery every three to five days.

Fred Jurick
Marine Advisory Extension Service
SEA Grant Program
Commercial St —Wharf
Eureka, CA 95501
(916) 443-8369

——The Albacore Fisheries Investigation, National Marine Fisheries Service, Scripps Institute of Oceanography, La Jolla

Under the direction of Dr Michael Laurs, the project at Scripps has been funded to evaluate what is being measured by the NOAA 6 weather satellite series Working with digital tapes and digital arrays of the sea surface temperature observations from the satellites, Dr Laurs has developed quantitative information about the usefulness of the thermal infrared imagery to locate albacore tuna

Although the project has worked with such organizations as the Western Fish Boat Owners Association, the American Fisheries Research Association, and the Inter-American Tropical Tuna Association, its emphasis is research, not service

Dr Michael Laurs
Albacore Fisheries Investigation
National Marine Fisheries Service
Scripps Institute of Oceanography
La Jolla, CA 92093
(714) 453-2820

Seasat Program

The NASA/NOAA Seasat program has been initiated as a "proof-of-concept" mission to evaluate the effectiveness of remotely sensing the ocean and related weather phenomena from a satellite platform in space All of the sensors on Seasat-1, launced June 1978, were developed on previous space and aircraft test programs. The satellite provides all weather, day and night measurements of sea surface temperature, surface wind speed/direction, sea state, and directional wave spectra. Unlike other weather satellites, Seasat will only provide data, not imagery

Commercial Demonstrations with Seasat

Two key programs are planned for data utilization during the Seasat mission. Foremost is a program with the commercial ocean community to test the utility of Seasat-1 data and to begin the transfer of ocean remote sensing technology to the civil sector These demonstrations are expected to begin in late 1978 or early 1979 Don Montgomery at the Jet Propulsion Laboratory is one of the coordinators for the commercial demonstration projects

Don Montgomery
NASA Jet Propulsion Laboratory
Mail Stop 264-420
Pasadena, CA 91103
(213) 354-2339

California industrial participants include:

Organization	*Project*	*Data Product*
Deepsea Ventures, Inc La Jolla, CA	East Pacific Ocean Mining	Real-time Non-real-time
Lockheed Ocean Lab San Diego, CA		
Union Oil Co Research Labs La Brea, CA	North Sea Oil and Gas	Non-real-time
Oceanroutes, Inc Palo Alto, CA	Marine Environmental Forecasting in the Gulf of Alaska	Real-time Non-real-time
Ocean Data Systems, Inc Monterey, CA	Ocean Thermal Energy Conversion	Real-time
Nat Marine Fisheries Serv Southwest Fisheries Lab La Jolla, CA	Tropical & Temperate Tuna Fisheries	Real-time
Humboldt State Univ Marine Advisory Service Eureka, CA	Pacific Salmoh Fishery	Real-time

Scientific Investigations with Seasat

The second major program planned for Seasat is a solicitation of investigations from the science community—investigations of high scientific merit utilizing Seasat-1 derived data This effort, led by NOAA, is also sponsored by NASA, U.S Geological Survey, the U S. Coast Guard, the Office of Naval Research and the National Science Foundation.

Investigations have been sought within five areas of research interest· Coastal Zone and Lakes, Open Ocean, Geodesy, Polar Regions, and Hydrology

Approximately one thousand proposals have been submitted by the scientific community, but no awards have been made for research as of September 1, 1978 Although it is uncertain how many of the proposals will be funded, the percentage may be very low

James Dunn
Ocean Experiments Manager
NASA Jet Propulsion Laboratory
Pasadena, CA 91103

Remote Sensing Facility for Ocean Research

Spring 1979, the Scripps Institute of Oceanography in La Jolla, California, will open the doors on a remote sensing facility for ocean research Federally funded by such supporters of oceanography as NASA, the Navy Office of Research, and the National Science Foundation, the facility will be the first of its kind and will offer hands-on experience to ocean remote sensing investigators.

The Scripps facility will have a tracking antenna and other tracking equipment to acquire imagery and data from the TIROS N (formerly NOAA 6) weather satellite series, from the NASA Nimbus G experimental weather satellite, and from Seasat

Along with the tracking equipment, the facility will house a computer system and computer programs designed specifically to handle weather satellite imagery and image data On hand will be a small complement of people to oversee the facility and train the investigators in the use of the equipment

The unique feature of the facility is the hands-on experience for users After a week or so of training, the investigators will be able to pursue research on their own Use of the facility will be determined on scientific merit of the research Current hopes are that the funding for the facility will preclude the need for user charges

Although the emphasis of the facility is Ocean Remote Sensing Research, there may be some limited operational use of the facility, depending upon the extent of research demands Dr Robert Bernstein is principal investigator on the project

Dr Robert Bernstein
Scripps Institute of Oceanography
Mail Stop A030
La Jolla, CA 92093
(714) 452-4233

Remote Sensing Projects, 1977-78 — Description and Contact Key

1 Update entire state wildlife habitat and detect change from 1965 inventory
Rod Goss, California Department of Fish and Game,
1416 Ninth Street, Sacramento, CA 95814
(916) 445-8393

2 Update land use information of Orange County by census tracts
Tom Tousignant, County Forecast Cost and Analysis,
515 North Sycamore, Santa Ana, CA 92701
(714) 834-5597

3 Develop procedural manuals for natural resource complex inventory and management, using Ventura County as study area
Doug Stow, Geography, Remote Sensing Unit, UC Santa Barbara,
Santa Barbara, CA 93106
(805) 961-4004

4 Detect seasonal or long-term change in outer continental shelf, all eight Channel Islands and the southern California Bight
Michael Mel, ESCATECH, 8405 Pershing, Suite 400,
Playa del Rey, CA 90291
(213) 822-5035

5 Assess and create a critical interim management plan for the deserts of California by studying "eco-boundaries," vegetation zones, the "Big Picture."
Hiram Johnson, Bureau of Land Management
1695 Spruce St., Riverside CA 92507

6 Basin study of the East Bay and Castro Valley watershed.
Dr Ralph V.R. Algazi, Dept of Electrical Engineering,
UC Davis, Davis, CA 95616
(916) 742-1444

7. Relationship of heavy metal uptake of plants to reflectance in the central San Francisco Peninsula
Dr R.J P. Lyon, Applied Earth Sciences, Stanford University,
Stanford, CA 94203
(415) 497-2747

8 Define separate plant communities and develop management implications in the Tahoe National Forest
Ike Parker, USFS Supervisor's Office, Tahoe National Forest,
Highway 49 and Coyote St., Nevada City, CA 95959

9 Ascertain how remote sensing can be used to enhance the framework in which water is managed in California.
Dr Ida R. Hoos, Space Sciences Lab, UC Berkeley,
Berkeley, CA 94720
(415) 642-2351

10 Study of the continental borderland of the Santa Barbara Channel for mapping and fault location
Bruce Luyendyk, Geology Dept , UC Santa Barbara
Santa Barbara, CA 93106
(805) 961-3009

11 Development of a decision-oriented resource information system (DORIS) for Ventura County
Robert Faulk, Ventura Co Flood Control,
597 E Main St , Ventura, CA 93001
(805) 648-6131

12 Study of Kern County watershed runoff
Robert Sasso, Geography Remote Sensing Unit, UC Santa Barbara, Santa Barbara, CA 93106
(805) 961-3603

13. Determine soil moisture from a radar system that may be on Space Shuttle, using 12 square miles along one agricultural area transect
Susan G Atwater, Geography Remote Sensing Unit, UC Santa Barbara Santa Barbara, CA 93106
(805) 961-4004

14 Feasibility and operational utility of Landsat imagery for cotton mapping in California, using agricultural areas of the San Joaquin Valley on a county basis
Tara L Hardoni, Geography Remote Sensing Unit, UC Santa Barbara, Santa Barbara, CA 93106
(805) 961-4004

15 Study in the Spanish Creek area of the Feather River Watershed to determine what percentage of water runs off or is made available from a given level of precipitation.
Siamak Khorram, Remote Sensing Research Program, Space Sciences Lab, Room 260, UC Berkeley, Berkeley, CA 94720
(415) 642-2351

16 Determine agricultural water demand in the agricultural area of the Central Valley and the 14 northern California counties
Sharon Wall, Remote Sensing Research Program, Space Sciences Lab, Room 206, UC Berkeley, Berkeley, CA 94720
(415) 642-2351

17 Initiate a total fuel management program in the northeastern quarter of Mendocino County
Andrew Benson, Remote Sensing Research Program, Space Sciences Lab, Room 206, UC Berkeley, Berkeley, CA 94720
(415) 642-2351

18 Determine moisture content of live forest fuels, using ten National Forest sites in California.
Susan Atwater, Geography Remote Sensing Unit, UC Santa Barbara, Santa Barbara, CA 93106
(805) 961-4004

19 Set up a vegetation monitoring system to accompany a water well drilling system in a coastal slough area
Susan Atwater, Geography Remote Sensing Unit, UC Santa Barbara, Santa Barbara, CA 93106
(805) 961-4004

20 Develop a driving energy balance snowmelt model for large areas
Jeff Dozier, Dept of Geography, UC Santa Barbara, Santa Barbara, CA 93106
(805) 961-3663

21 Role of government in allocation of resources to technological innovation
no contact

22 Developing and demonstrating an institutional mechanism for transferring remote sensing techniques
Donna Hankins, Remote Sensing and Technology Transfer Project Center for Community Development, Humboldt State University, Arcata, CA 95521

23 Compare VHRR, Landsat and GOES satellite data to study surface thermal and color radiants related to regional tuna catch data for applications to fisheries research and resource management

Dr M Stevenson, Inter-American Tropical Tuna Commission
c/o Scripps Institute of Oceanography,
La Jolla, CA 92037

24. Explore using the extent of snow covered area obtained from satellite imagery in California's snowmelt runoff forecasting procedure

A.J Brown, State Dept. of Wate Resources,
1416 Ninth St , Sacramento, CA 95814

25. Study of coastal and shallow water geology using satellite imagery

D S. Gorsline, University of Southern California, School of Letters, Arts, and Science,
3551 University Ave., Los Angeles, CA 90007

26. Determine the atmospheric aerosol optical thickness over the ocean, using Landsat, to validate a technique which will provide daily global maps of aerosol isopleths over the ocean.

M Griggs, Science Applications, Inc ,
1200 Prospect St., La Jolla, CA 92037

27 Devise systems for providing forest managers with static inventory and dynamic biological response information needed for decision-making

E L Amidon, U S. Dept of Agriculture, Pacific Southwest Forest Experiment Station,
P O Box 245, Berkeley, CA 94701

28 Determine, for forested areas, the type of aerial photography from which information essential in the practice of forestry can be most accurately and readily extracted.

R.N. Colwell, UC Berkeley, Agricultural Experiment Station,
Berkeley, CA 94720

29 Determination of the accuracy and ease with which various forest characteristics can be identified and/or measured by various remotely-situated electromagnetic sensors.

R.N. Colwell, UC Berkeley, Agricultural Experiment Station,
Berkeley, CA 94720

30 Develop techniques for using Landsat digital data to identify, classify, and map major wetland types identified by the U S Fish and Wildlife Serv as being of importance to a national inventory of wetlands

D P Burcham, California Institute of Technology, NASA Jet Propulsion Lab,
1201 East California Blvd , Pasadena, CA 91109

31 Multiple input land use analyses for metropolitan/regional area applications, using the greater Los Angeles area

D P Burcham, California Institute of Technology, NASA Jet Propulsion Lab,
1201 East California Blvd , Pasadena, CA 91109

32 Review and synthesis of existing historic, seismic, geologic, and geodetic records of all faults with known or suspected Late Quaternary activity

V R Todd, U S Geological Survey,
8604 La Jolla Shores Dr , San Diego, CA 92037

33 Assessing and analyzing all resources of California's forest land and developing a system to update this information on a regular basis

Dale Wierman, CA Dept of Forestry, FRAP Section,
1416 Ninth St , Sacramento, CA 95814

34 Inventorying timber, in particular timber volume by correlating consistant light reflectance patterns from Landsat with slope, aspect, and elevation as supplied by the U S G S digital terrain tapes
Dr A Strahler, Geography Remote Sensing Unit, UC Santa Barbara, Santa Barbara, CA 93106
(805) 961-4004

35. Assessing the impact of clear-cutting on tributary degradation as part of an overall fisheries resource study on the Hoopa Valley Indian Reservation and the Klamath Extension
Ken Mayer, Remote Sensing Project, Center for Community Development, Humboldt State University, Arcata, CA 95521
(707) 826-3731

36 Inventory of forest cover types, correlated with wildlife habitat on the Hoopa Valley Indian Reservation, Humboldt County
Jeff Soto, Forestry Department, Humboldt State University, Arcata, CA 95521
(707) 826-3935

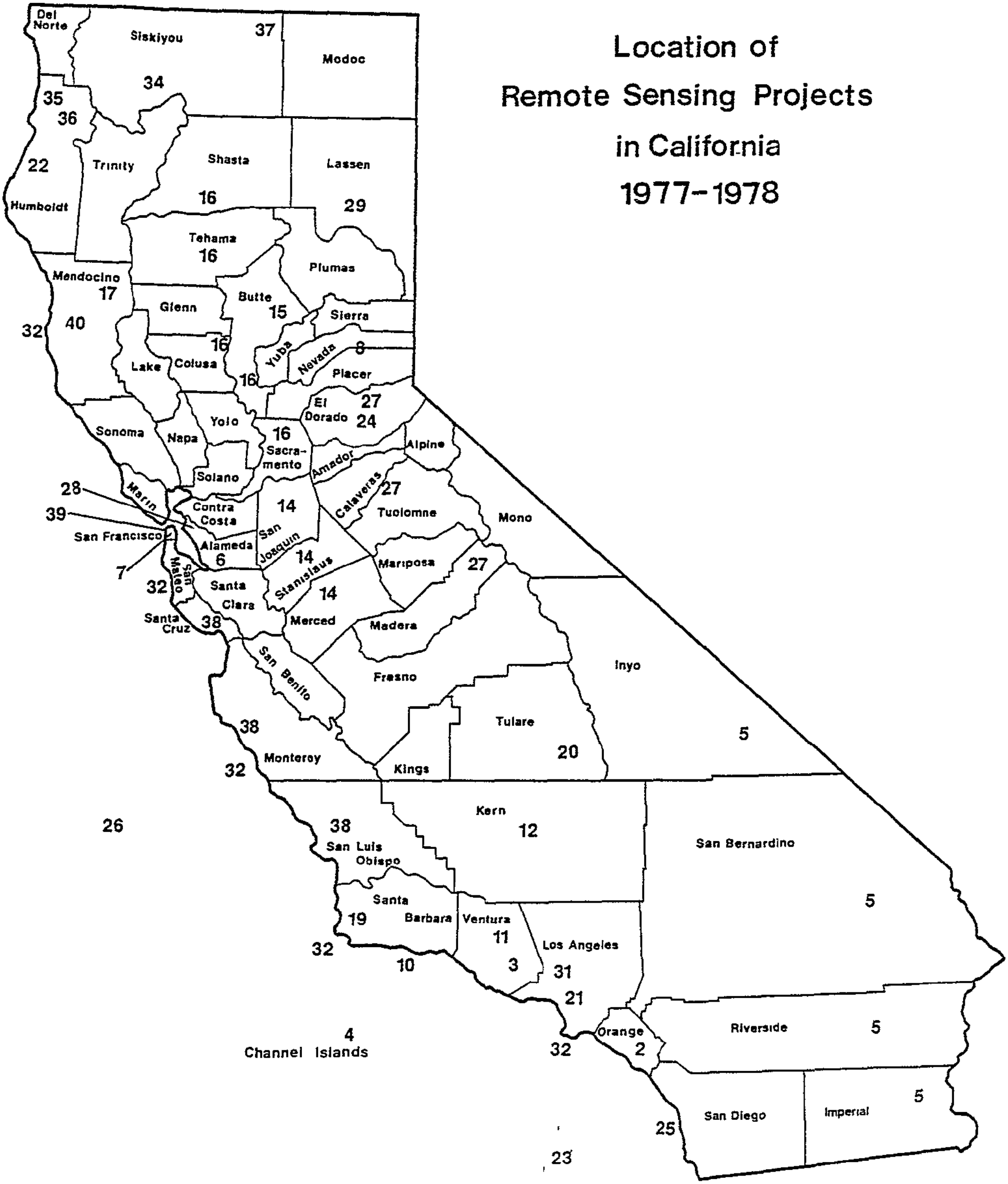
37 Surface area study of the Tule Lake Reservoir
Lowell Field, Water Resources Control Board, Division of Water Rights, P.O Box 100, Sacramento, CA 95801
(916) 920-6471

38 Inventory of hardwood forests in the four counties under the Central Coast Resource Conservation and Development Commission, for fire impact
Susan Norman, Western Regional Applications Program, Mail Stop 242-4, NASA Ames Research Center, Moffett Field, CA 94035

39 Water Quality Mapping and Location of Entrapment Zone in San Francisco Bay Delta using Remote Sensing Techniques
Siamak Khorram, Remote Sensing Research Program Rm. 260, Space Sciences Lab, UC Berkeley, Berkeley, CA 94720

40 Assessment of Wildlife Habitat Potential in Mendocino County using Remote Sensing Techniques
Edwin F Katibah, Remote Sensing Research Program, Rm 260, Space Sciences Lab, UC Berkeley, Berkeley, CA 94720

Location of Remote Sensing Projects in California 1977-1978

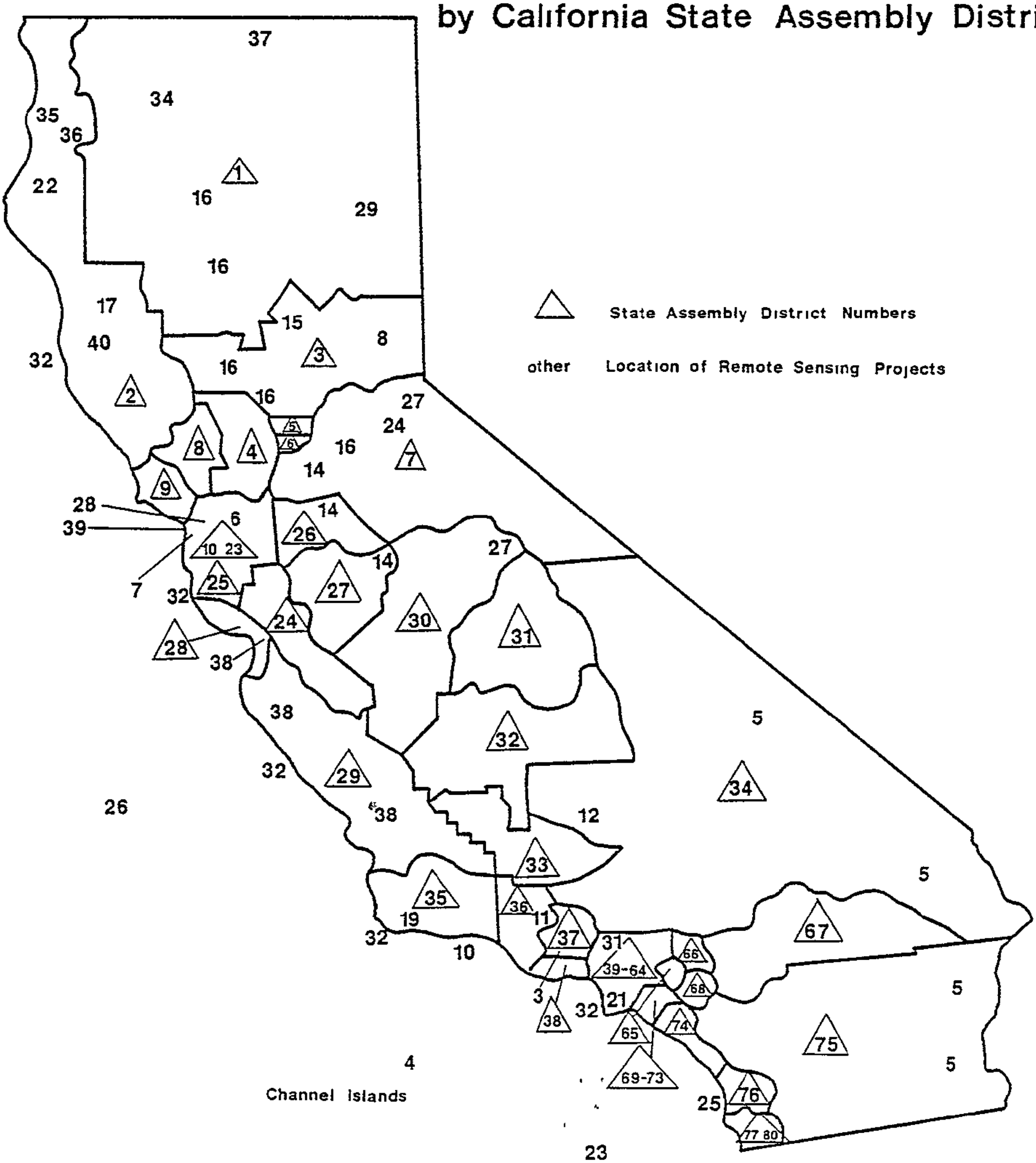


Project numbers 1 5 30 33 are statewide, number 32 is the coastal area

Numbers on this map correspond with the Description and Contact Key

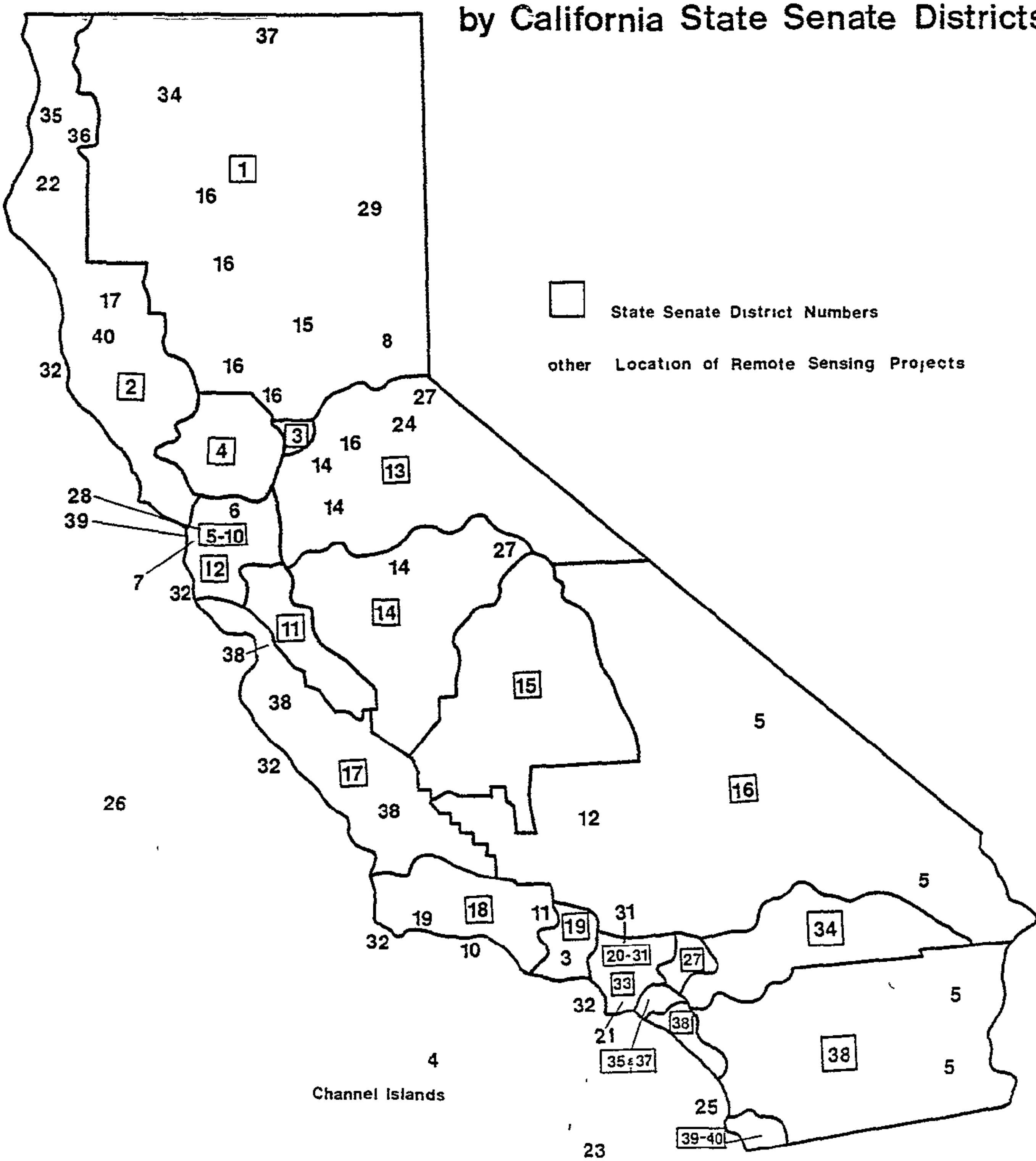
358

Remote Sensing Projects
1977 - 1978
by California State Assembly Districts



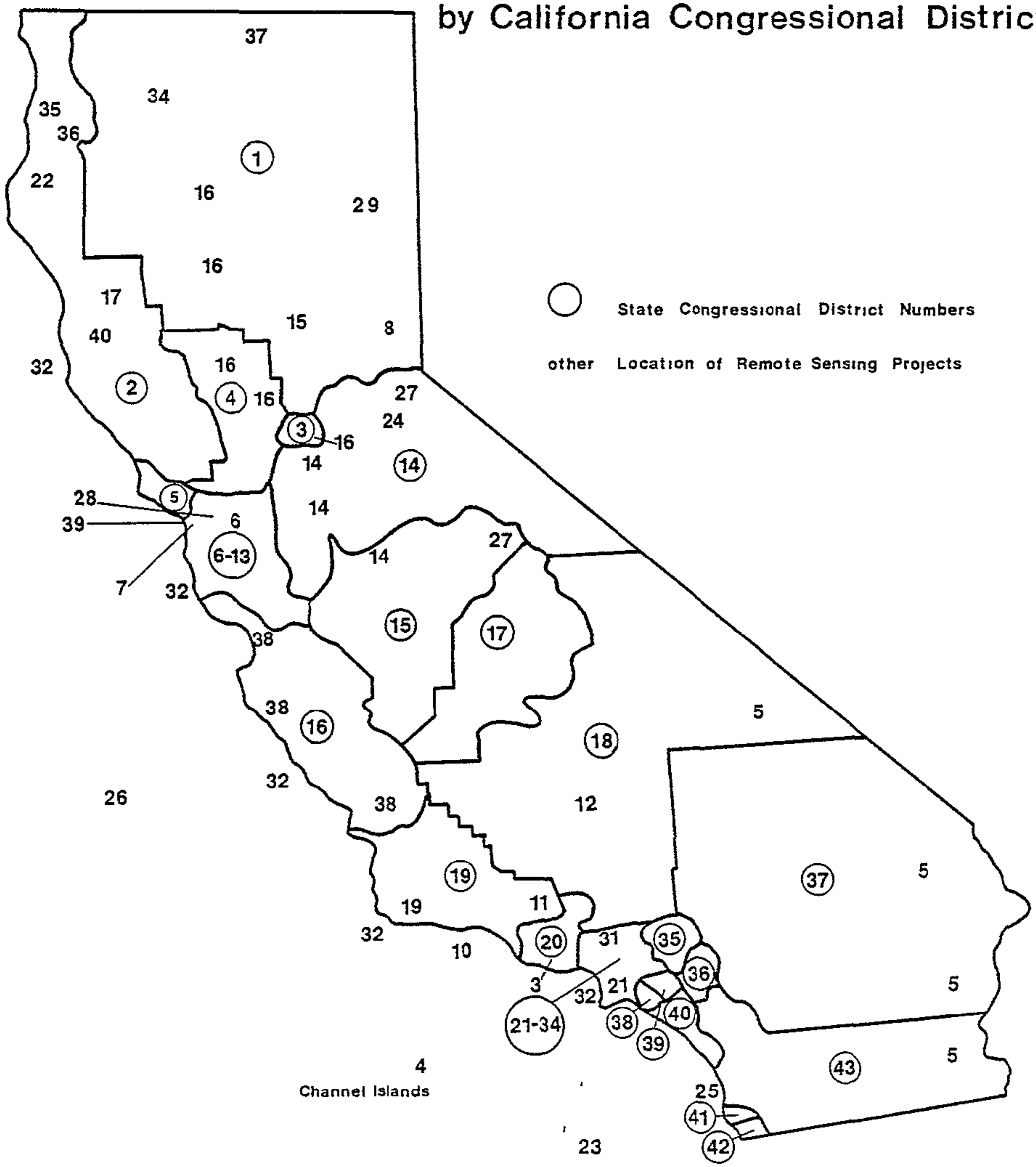
Project numbers correspond with the Desription and Contact Key

Remote Sensing Projects
1977–1978
by California State Senate Districts



Project numbers correspond with the Description and Contact Key

Remote Sensing Projects
1977 - 1978
by California Congressional Districts



Project numbers correspond with the Description and Contact Key

SECTION III — INDUSTRY INVOLVEMENT IN REMOTE SENSING

INDUSTRIAL INVOLVEMENT IN REMOTE SENSING

Industry Providing the Products and Services

from a presentation by Lowell H Brigham, General Electric, Space Division, at the Landsat-C Educators Conference, March 1978

Whether we like it or not, technology has a continually expanding influence on modern living, and the technologies we live with are becoming more sophisticated and complex. Remote sensing tools in general, and the Landsat program, in particular, have been born for their time

Today we have a growing concern for critical non-renewable resources, for renewable resources, as in worldwide food production, and for preservation of our air, land and water environment Remote sensing is one of the tools to help accomplish the awesome task of inventorying and continuously monitoring our resources

Ten years ago, the term "remote sensing" required an explanation Today universities are turning to the data, both images and in digital tape format, as a basis for graduate and undergraduate source material in the related biological and physical sciences

Ten years ago there was little industry participation beyond the production of hardware Today there are hundreds of us in large corporations and small that are providing the hardware, software, and analytical services associated with the technology. Regardless of affiliation, industry is very product-oriented.

One of industry's roles is to apply resources to advance the state-of-the-art For example, nearly all of the hardware and software systems associated with the Landsat program were provided by the private sector However, their development was funded by NASA and much of the technology that was employed can be traced back to the Department of Defense In that instance and in others, industry acted as an implementor But industry has also added in-house resources to the technology's development.

Technology Transfer

By working with and for clients, industry transfers technology to the user community In some cases, technology transfer results from an analysis project performed with participating client personnel In other cases, industry provides demonstrations of system capabilities, run training programs, and sell hardware or software products In nearly every case, technology transfer needs to be a two-way street Industry has to learn the customer's requirements at the same time that the user learns about industry's system capabilities or analytical techniques

Finally, industry maintains a pool of experienced personnel and systems to service those organizations that do not have an in-house capability or that have a demand exceeding their capability

The Landsat program is full of industry role examples

1) The Multispectral Scanner and Thematic Mapper (for Landsat-D) represent

research and development that have advanced sensor state-of-the-art

2) The Landsat spacecraft with all of its components plus all of the digital data processing and analysis systems represents industrial efforts to provide hardware and software systems.

3) Sales of image analysis systems to operational federal agencies and to petroleum exploration companies represents technology transfer

4) and finally, the production of geologic studies, land use maps and forest inventories represents industry providing a service to the user community

Industry is a partner in remote sensing technology. It has been a partner with NASA in developing and producing the Landsat system. Now it is time to develop the same type of partnership with the user community to insure that the available technology will be successfully applied and the requirements for new technology will be identified.

Specific Industries Involved in Remote Sensing

There are six major industrial segments participating in the technology transfer process Representatives of each group are listed under each segment.

1) Major Aerospace firms providing systems and/or services relating to remote sensing technology

General Electric Company
5030 Herzel Place
Beltsville, MD 20705
Lowell Brigham, Space Division

Lockheed Electronics Company
16811 El Comino Real
Houston, Texas 77058
Robert Tokerud

TRW System Group
One Space Park
Redondo Beach, CA 90278
Richard Maher

2) Firms producing digital image analysis systems and/or providing image analysis services

Comptal Corporation
169 North Halstead
Pasadena, CA 91107
Richard Jones

Computer Sciences Corporation (CSC)
8728 Colesville Road
Silver Springs, MD
Robert Cecil

ESL, Incorporated
495 Java Drive
Sunnyvale, CA 94086
Dr. James Burke

International Business Machines (IBM)
1800 Frederic Pike
Gaithersburg, MD 20760
Charles Gilmore

Control Data Corporation
2800 E Old Shakopee Road
Minneapolis, Minnesota 55440
George Swanlund

International Imaging Systems (I^2S)
650 N Mary Avenue
Sunnyvale, CA 94086
Reese Jensen

Interpretation Systems, Inc. (ISI)
P O Box 1007
Lawrence, Kansas 66044
Jerry Lent

Spectral Data Corporation
112 Parkway Drive South
Hauppauge, N Y 11787
Tony Wenderroth

Spatial Data
508 Fairview Avenue
Goleta, CA
David Rutland

3) Firms providing analytical services including remotely sensed data analysis plus scientific discipline consultation

Calspan Corporation
P O Box 235
Buffalo, N Y 14221
John Walker

Dames and Moore
100 Church Street
New York, N Y 10007
Robert Reed

Denver Mineral Exploration Co
1100 W Littleton Blvd , Suite 103
Littleton, Colorado 80120
Dr Carl Kober

Earth Satellite Corporation
7222 47th Street
Washington, D C 20015
Dr John Everett

Geospectra Corporation
320 North-Main, Suite 301
Ann Arbor, Michigan 48108
Dr Robert Vincent

Geo Images
P O Box 576
Altadena, CA 91001
Dr. A F H. Coetz

Earth Science Consulting and Technology (ESCA-TECH)
3001 Red Hill Ave., Suite 212
Costa Mesa, CA 92626
David Steller

Pattern Recognition — Technology & Application
S S Viglione and Associates
551 Peralta Hills Drive
Anaheim, CA 92807
Sam S Viglione

Barringer Research Inc
1536 Cole Blvd , Suite 330
Golden, Colorado 80401
Dr Anthony Barringer

Environmental Research & Technology
696 Virginia Road
Concord, Mass 01742
Michael Smallwood

Resources Development Associates
P O Box 239
Los Altos, CA 94022
Robert Campbell

4) Firms providing geo-referenced data base systems and/or services allowing access to multiple layers of geo-coded data including remotely sensed images

Comarc Design Systems
315 Bay Street
San Francisco, CA 94133
Ronald Walters

Environmental Systems Research Inst
380 New York Street
Redlands, CA 92373
Jack Dangermond

5) Not for Profit organizations (that are independent of federal or state agencies) providing a remote sensing technology transfer function such as image analysis services.

Battelle Memorial Institute
Columbus Laboratory
505 King Avenue
Columbus, Ohio 43201
George Wukelic

Environmental Research Institute of Michigan (ERIM)
P O. Box 618
Ann Arbor, Michigan 48107
Dr. Donald Lowe

Socio-Tech Associates for Research (STAR)
126 Second Avenue #3
San Francisco, CA 94118
George Small

6) Firms producing other devices related to remote sensing such as digital sensors and digital image output devices

DAEDALUS, Inc
P.O Box 1869
Ann Arbor, Michigan 48106
John Smith

OCEAN AND EARTH DATA RESOURCES

Partial listing of industries and non-profit organizations in California that represent significant capabilities in data collection, processing and analysis (From an Ocean Data Resources pamphlet printed for the U S Committee on Commerce, March, 1975)

Ametek, Inc.
Straza Division,
Box 666
El Cajon, CA 92021

Applied Oceanographics, Inc
5055 North Harbor Dr
San Diego, CA 92106

Atlantis, Inc
9015 Wilshire Blvd
Beverly Hills, CA 90211

Bechtel
Marine Department
50 Beale Street
San Francisco, CA 94119

Bendix-United
Geophysical Corp
2650 E Foothill Blvd
Pasadena, CA 91109

J G Boswell Co
4600 Security Pacific Plaza
333 South Hope Street
Los Angeles, CA 90071

Cahn Instruments
Division of Ventron Corp
7500 Jefferson St
Paramount, CA 90723

Carlesberg Petroleum Corp
1801 Century Park West
Los Angeles, CA 90067

Chevron Overseas Petroleum Inc
Room 1108
555 Market Street
San Francisco, CA 94105

Chevron Oil Research Co
La Habra Laboratory
P O Box 446
La Habra, CA 90631

Clean Bay, Inc
Room 220
1882 Diamond Blvd
Concord, CA 94520

Comarc Design Systems
315 Bay Street
San Francisco, CA 94133

Dana Point Marine Research Lab
P O Box 367
Dana Point, CA 92629

Defense Technology Laboratories
FMC Corporation
Ordnance Group
P O Box 1202
San Jose, CA 95108

Dunegan Research Corp
2044 Research Drive
Livermore, CA 94550

Earth Science
Consulting & Technology
2300 Cherry Industrial Circle
Long Beach, CA 90805

Environmental Systems
Research Institute
380 New York Street
Redlands, CA 92373

Escatech Corp
840 South Pershing
Playa del Rey, CA 90291

ESL, Inc
495 Java Drive
Sunnyvale, CA 94086

FMC Corp
1105 Coleman Ave
San Jose, CA 95110

Fairchild Camera &
Instrument Corp
Controls Division
Transducer Plant
423 National Avenue
Mountain View, CA 94040

Far West Laboratory
1855 Folsom St
San Francisco, CA 94103

General Dynamics Corp
Marine Technology Center
2930 North Harbor Drive
San Diego, CA 92101

General Motors Corp
AC Electronics Defense
Research Laboratories
Goleta, CA 93017

General Oceanographics, Inc
2172 Dupont Drive
Suite 13
Newport Beach, CA 92660

Global Marine, Inc
650 South Grand Ave
Los Angeles, CA 90017

Grefco, Inc
630 Shatto Place
Los Angeles, CA 90005

Gulf Oil Corp
P O Box 1392
Bakersfield, CA 93302

International Environmental
Analysis (Ecographics)
P O Box 706
La Jolla, CA 92038

Intersea Research Corp
11760 Sorrento Valley Rd
San Diego, CA 92121

Interstate Electronics Corp
Oceanics Division
707 East Vermont Ave
Anaheim, CA 92803

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91103

Kennecott Exploration, Inc
Ocean Operations Division
Ocean Resources Department
10306 Roselle Street
San Diego, CA 92121

Lear Siegler, Inc
3171 South Bundy Drive
Santa Monica, CA 90406

Lewis & Lewis Offshore, Inc
P O Box 820
271 South Hemlock St
Ventura, CA 93001

Litton Industries
Data Systems Division
P O Box 7601
Van Nuys, CA 91409

Living Marine Resources, Inc
11339 Sorrento Valley Rd
San Diego, CA 92121

Lockheed Missiles & Space Co
P.O Box 504
Sunnyvale, CA 94088

Lockheed Ocean Laboratory
3380 Harbor Drive
San Diego, CA 92101

Marine Advisers, Inc
Division of Bendix
P O Box 690
Solana Beach, CA 92075

Marine Dynamics
Box 521
Long Beach, CA 90801

Marine Experimental Services
P O Box 9466
San Diego, CA 92109

Marineland of the Pacific
Biological Laboratory
Palos Verdes Dr South
Palos Verdes Estates, CA 90274

Marine Resource Consultants, Inc
225 Santa Monica Blvd
Santa Monica, CA 90401

Marine Technique, Inc
4607 Toni Lane
San Diego, CA 92115

McCulloch Oil Corp
10880 Wilshire Blvd
Los Angeles, CA 90224

Meteorology International
P O Box 349
419 Webster Street
Monterey, CA 93940

Meteorology Research, Inc
P O Box 637
464 West Woodbury Rd
Altadena, CA 91001

National Research Center
680 Wilshire Place
Los Angeles, CA 90005

North American Weather Consultants
Aerometric Research, Inc
Santa Barbara Municipal Airport
Goleta, CA 93017

Newport Laboratories, Inc
630 East Young Street
Santa Ana, CA 92705

North American Rockwell Corp
Autonetics Division
3370 Miraloma Avenue
Anaheim, CA 92803

Northwest Oceanographers Inc
1045 Gayley Avenue
Suite 205
Los Angeles, CA 90024

Occidental Petroleum Corp
6000 Stockdale Highway
Bakersfield, CA 93309

Ocean Resources Inc
3344 Industrial Court
San Diego, CA 92121

Ocean Routes, Inc
1534 Page Mill Road
Palo Alto, CA 94304

Ocean Science Capital Corp
459 Hamilton Ave
Palo Alto, CA 94301

Oceanographic Engineering Corp
Division of Dillingham Corp
P O Box 1560
La Jolla, CA 92038

Oceanographic Services Inc
Subsidiary of Global Marine, Inc
135 East Ortega Street
Santa Barbara, CA 93101

Pacific Aerial Surveys
Hammon, Jensen, Wallen & Assoc
8407 Edgewater Dr
Oakland, CA 94621

Pacific Gas & Electric Co
245 Market Street
San Francisco, CA 94106

Pacifica Coastal & Marine Mapping Co
Pacifica Ocean Research, Inc
2980 Plaimer
Palm Springs, CA 92262

The Rath Co
P O Box 226
7445 Girard Avenue
La Jolla, CA 92037

Resources Development Assoc
P O Box 239
Los Altos, CA 94022

Santa Catalina Marine
Biological Laboratory
Big Fisheries Cove
Santa Catalina Island
P O Box 398
Avalon, CA 90704

Scripps Institute of Oceanography
La Jolla, CA 92037

Sierra Club
1050 Mills Tower
San Francisco, CA 94104

System Development Corp
2500 Colorado Ave
Santa Monica, CA 90406

Systems Consultants Inc
211 South U Street
Eureka, CA 95501

TRW Systems
Systems Engineering and
Integration Division (SEID)
One Space Park
Redondo Beach, CA 90278

Tetra Tech, Inc
7730 Herschel St
La Jolla, CA 92037

Texaco, Inc
3350 Wilshire Blvd
Los Angeles, CA 90005

United Geophysical Corp
Subsidiary of the Bendix Corp
2650 East Foothill Blvd
Pasadena, CA 91109

Western Geophysical Co
Litton Industries
933 North LaBrea Avenue
Los Angeles, CA 90038

Woodward-Clyde Consultants
Western Region
Suite 700
Two Embarcadero Center
San Francisco, CA 94111

Industry Using Remote Sensing

There is a distinction between the industries that provide remote sensing products and services and the industries that use the technology for specific applications Most of this second industrial use of remote sensing is proprietory, however, each can be-characterized

Industries that employ remote sensing extensively often have in-house capability to interpret and/or process the imagery Or they may have a remote sensing expert or manager in-house, but contract for products and services with other industries. Industries that use remote sensing on a limited basis usually contract for services as they are needed

Resource Exploration

Industries that engage in resource exploration are the most extensive users of remote sensing As Dr. Floyd Sabins, Chevron Oil Research Company, points out in his textbook, *Remote Sensing, Principles and Interpretation,*

> "Private industry is the largest single purchaser, in dollar value, of remote sensing imagery from the EROS Data Center, with the principal application being for oil and mineral exploration The extractive industries also employ contractors to acquire photography, thermal IR, and radar imagery in areas of exploration interest These investments by cost-conscious industry are evidence for the exploration value of remote sensing."

Although many of the resource exploration companies are located in California, there is little exploration in the state, using remote sensing Thermal infrared photography has been used to study the geothermal fields in the Imperial Valley and at the Geysers in northern California At the Geysers area, hot springs were detected on thermal IR images, but the images failed to reveal a significantly higher surface temperature in the overall Geysers area

Agriculture

Infrared photography, flown at low altitudes, appears to be the most useful remote sensing tool in California agribusiness. Although there have been large area agricultural experiments using Landsat—like LACIE, a project to measure worldwide wheat production—Landsat seems to have too many limitations for agriculture at this time

The biggest single problem is the timeliness of the data Crops must be studies on a week to week, month to month basis, especially to spot disease Even though Landsat imagery is recorded over an area every nine days, it usually takes at least a month for the data to make its way to the user Then there is the additional time needed to process the data

To avoid the problem of timeliness, some agribusiness in California like J G Boswell Company, wheat and cotton producers fly their fields whenever necessary and take infrared photography of the crops In this way they can have the film back in a matter of days, at far less cost and with much better resolution than with Landsat

Forest Products Industry

The low altitude aerial photograph, mostly black and white, has long been the principal remote sensing aid in forest inventory and timber volume assessment Some of the larger northern California timber companies such as Arcata National and Louisiana Pacific are beginning to use high altitude (U-2) infrared photography, either prints or transparencies, for large area studies But there has been no move as yet to incorporate Landsat into their programs

The St Regis Corporation is participating in an ASVT with NASA to use Landsat in inventorying all of the company's timber holdings in the southeastern United States Although St Regis also has timber holdings in California, the interest here is a geo-based information system rather than any Landsat demonstration

The move toward computerized geo-based information systems is also shared by Georgia Pacific Corporation, the Simpson Timber Company, and Arcata National Corporation. (Section V, Geo-based Information Systems)

Explanation and Request

There may be many other small and large industries in California using remote sensing tools However, because of the proprietary nature of most companies' work, it has been difficult to paint a true picture in this survey.

California industries that would like to include their remote sensing activities in future updates of this survey should contact either the Remote Sensing Project at Humboldt State University, Arcata, California, or the Environmental Data Center, Sacramento

SECTION IV — COLLEGES AND UNIVERSITIES TEACHING REMOTE SENSING

WHERE REMOTE SENSING IS TAUGHT IN CALIFORNIA

Remote sensing and photogrammetry are an integral part of many college and university programs in California. Two surveys conducted between May 1975 and February 1976 by Timothy Bidwell and Stanley Morain *(Journal of Photogrammetric Engineering and Remote Sensing,* March 1977) found that twenty-three institutions of higher learning in California had courses or related courses in remote sensing and/or photogrammetry

Our survey finds that the number of schools in 1977-78, that include some aspect of remote sensing in their curriculums is almost three times the 1975-76 figure However, only a handful of universities offer courses in image processing of remotely sensed data

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Special Programs

Photogrammetry

A bachelor's degree in Surveying and Photogrammetry is offered at CSU Fresno in their Civil Engineering Department And an advanced degree in Civil Engineering with an emphasis in Photogrammetry is offered in the College of Engineering at UC Berkeley

Remote Sensing

Advanced degrees in remote sensing are offered at two California universities, UC Santa Barbara and Stanford University At UC Santa Barbara, the degree is offered in Remote Sensing/Geography through that school's Geography Remote Sensing Unit.

At Stanford, the master's degree in remote sensing is a CORE program in the Department of Applied Earth Sciences

Image Processing

Only two universities in California offer advanced course work or instructional programs in Image Processing as related to remote sensing applications, UC Santa Barbara and Stanford University Both of these schools also process data for federal, state and local agencies and governments

Geography Remote Sensing Unit
Geography Department
UC Santa Barbara
Santa Barbara, CA 93106
Dr Jack Estes (805) 961-3649

Remote Sensing Laboratory
School of Earth Sciences
Stanford University
Stanford, CA 94203
Dr Ronald Lyon (213) 497-3262

Two other universities in California have centers for analyzing and processing remote sensing data, but these centers do not teach courses at their universities Their principal emphasis is research Instead of regular instruction, each of these centers offers short courses in the technology throughout the year These two centers are the Space Sciences Laboratory at UC Berkeley and the Image Processing Institute at the University of Southern California

Remote Sensing Research Program Space Sciences Laboratory UC Berkeley Berkeley, CA 94720 Dr Robert Colwell (415) 642-1353	Image Processing Institute University of Southern California University Park Los Angeles, CA 90007 Dr William Pratt (213) 746-5514

UC San Diego's Scripps Institute of Oceanography will soon have a remote sensing facility for ocean research (Section II, Weather Satellite Users). Its primary purpose will be research, not instruction

College and University Listings

Listed alphabetically within university and college systems are the schools in California where remote sensing and/or photogrammetry are taught Also included in this list are courses related to those subjects and the most recent school year they were offered

Each course name is followed by initials that describe the course's emphasis A small letter "r" after these initials means that the course is *related* to that emphasis

Photogrammetry —	PG or	PGr
Photo Interpretation —	PI	PIr
Remote Sensing —	RS	RSr
Image Processing —	IP	IPr

California State Universities & Colleges

CSC Bakersfield (78 79)
Earth Science
201-Basic Principles of Geology (RSr)
203-Basic Principles of Physical Geography (RSr)
211-Concepts in Spatial Geography (RSr)

CSU Chico (77-79)
Geography
204-Biogeography (PIr)
214-Aerial Photo Interpretation (PI)
219-Advanced Research Techniques (PI,RS)
Civil Engineering
272 Photogrammetry (PG)

CSU Dominguez Hills (78-79)
Geography
208-Maps, Photographs and Remote Sensing (PG,RS)
248-Documentation Photography (PG)

CSU Fresno (78-79)
Geography
105-Aerial Photograph Interpretaion (PI)
106-Advanced Aerial Photographic Interpretation and Remote Sensing of the Environment (PI,RS)
Geology
140 Interpretation of Geologic & Topographic Maps (PIr)
Civil Engineering
3-Fundamentals of Photogrammetry (PG)
5-Photogrammetric Instrumentation (PG)
6-Photographic Processes in Engineering (PGr)
103 Advanced Photogrammetry (PG)
106-Cartographic Techniques & Map Reproduction (PG)
107-Electronic Distance Measurements (PGr)
Offers degree in Surveying and Photogrammetry

CSU Fullerton (77-79)
Geography
280a-Interp of Maps & Aerial Photographs (PI)
384-Air Photo & Image Interpretation (PI)
386-Data Processing for Geographic Information (IPr)
482 Advanced Cartography-Thematic Mapping (PGr)
488 Land Use Analysis (PIr)
Earth Sciences
121-Earth Science Laboratory (PIr)
385-App of Computers to Earth Sciences (IPr)
456-Advanced App Geophysics (PI)
Computer Science
465-Principles of Computer Graphics (IPr)

CSU Hayward (78-79)
Geography
3410-Aerial Photo Interpretation (PI)
Earth Sciences
3110-Principles of Geomorphology (PIr)
4425 Remote Sensing of Earth Environments (RS)
3910-Geologic Field Methods (PIr)

Humboldt State Univ (78-79)
Forestry
106-Air Photo Interpretation (PI)
206-Advanced Principles in Remote Sensing (RS)
Geology
100-Geomorphology (PIr)
101-Methods of Air Photo Interpretation (PI)
Geography
1-Elements of Mapping (PGr)
102-Field Techniques (PIr)
Natural Resources
106-Remote Sensing of the Environment (RS)
107-Remote Sensing Workshop (RS)

CSU Long Beach (78-79)
Geography
483-Aerial Photo Interpretation & Remote Sensing (PI,RS)
Geology
Photogeology and Geomorphology (PIr)
Civil Engineering
427-Engineering Photogrammetry (PG)

CSU Los Angeles (78-79)
Geography
210-Map Reading and Photo Interpretation (PI)
465-Air Photo Interpretation (PI)
466-Remote Sensing of the Environment (RS)
Geology
483 Photogeology (PIr)

CSU Northridge (78-79)
Geography
205-Elementary Mapping (air photo interp) (PIr)
307-Air Photo Interpretation (PI)
407-Remote Sensing (RS)
462-Computer Applications in Geography (IPr)
Geology (Geosciences)
331-Photogeology (PIr)

CSU Sacramento (77 78)
Geography
103-Map & Air Photo Interpretation (PI)
Engineering
105-Technical Photography (PIr)
187-Environ Remotely Sensed Using Satellites/Aircraft (RS)
225 Remote Sensing of Environmental Quality (RS)
Civil Engineering
253 Advanced Environ Quality Analysis (RSr)

CSC San Bernardino (78-79)
Geography
370 Soils & Landforms (tech inc photo interp) (PIr)

San Diego State University (78 79)
Geography
180-Basic Map & Aerial Photographic Reading (PI)
382-Use & Interpretation of Aerial Photos (PI)
587-Remote Sensing of the Environment (RS)
588-Adv Remote Sensing of the Environment (RS)
687—Seminar in Remote Sensing of the Environment (RS)
Geology
505 Photogeology (PIr)

San Francisco State University (77 78)
Geography
103 Geographic Techniques (PIr)
607-Map Projections (PIr)
608-Interpretation of Aerial Photography (PI)
610 Remote Sensing of the Environment (RS)

San Jose State University (78 79)
Geography
181-Map Interpretation and Use (PIr)
183 Remote Sensing (RS)
188 Land Use Mapping & Geographic Info Systems (PI,RS,IPr)

Geology
136-Map and Aerial Photo Interpretation (PI)
Environmental Studies
181-Environmental Information Center (RSr)

Sonoma State University (77-78)
Geography
204 Man and Environment (RSr)
307Earth A View from Space (RS)
308-Map & Air Photo Interpretation (PI)
Geology
308 Map & Air Photo Interpretation (PI)

CSC Stanislaus (78-79)
Geography
3710-Remote Sensing of the Environment (RS)

University of California

UC Berkeley (77-78)
Geology
116B-Geological Structures and Maps (PIr)
Civil Engineering
101 Elementary Photogrammetry (PG)
107-Air Photo Analysis & Interpretation (PI)
287A,B-Analytic Photogrammetry (PG)
288A,B-Analogue Stereorestitution Instruments and Stereotriangulation (PGr)
289-Adjustment Computations (PGr)
Forestry
102-Forest Photogrammetry (PG & PI)
202-Advanced Photo Interpretation (PI)
Geology
117-Geomorphology (PIr)
Computer Sciences
256 Computer Graphics (IPr)

UC Davis (77-78)
Geography
106-Interpretation of Aerial Photography (PI)
Geology
152-Photogeology & Remote Sensing (PIr,RS)

UC Irvine (77-78)
Social Ecology
E154-Environmental Applications of Remote Sensing Techniques (RS)

UC Los Angeles (78-79)
Geography
169-Earth from Above (RS)
269-Remote Sensing of the Environment (RS)
Geology (Earth & Space Science)
150-Remote Sensing for Earth Science (RS)
204-Advanced Remote Sensing (RS)

UC Riverside (78-79)
Earth Sciences
4 The Earth From Space (RS)
158 Remote Sensing of the Environment (RS)
107 Computer Applications in Earth Science (IPr)

UC San Diego (77-78)
Applied Physics & Information Sciences
141A-Optical Signal Processing (IPr)
243A,B Optical Systems (IPr)

UC Santa Barbara (78-79)
Geography
115A Geographic Photo Interpretation (PI)
115B-Geographic Remote Sensing Techniques(RS)
115C-Intermediate Geographic Remote Sensing Techniques (RS)
122A,B Field Snow Hydrology (RSr)
126 History of Cartography (RSr)
172,172L-Techniques of Geographic Data Analysis I & Laboratory (IPr)
173,173L-Techniques of Geographic Data Analysis II & Laboratory (IPr)
182 Principles of Landuse/Landcover Analysis (PI,IPr)
Graduate
214 Microwave Remote Sensing (RS)
215-Seminar in Remote Sensing (RS)
216-Remote Sensing Instrumentation and Software (RS,IP)
222-Spatial Decision Making (IP)
224-Spatial Statistics (IP)
228-Multidimensional Analysis of Spatial Problems (IP)
273-Natural Vegetation Classification, Inventory, & Dynamics (IP)
275-Seminar in Geographical Information Systems (IPr)
Offers Masters degree in Geography/Remote Sensing
Engineering
227A-Computer Graphics (IPr)
278-Computer Image Processing (IP)

UC Santa Cruz (77-78)
Environmental Studies
100-Intro to Environ Field Methods (PIr)

California Poltechnic State Universities

CA Polytechnic Institute-Pomona (77-78)
Geography
310-Earth from Space (RS)
410-Photographic Remote Sensing (PI,RS)

CA Polytechnic Institute-San Luis Obispo (77-78)
Agricultural Engineering
445-Remote Sensing (RS)
345-Aerial Photogrammetry (PG)
Agricultural Management
250-Computer Application to Agric (IPr)
350-Computer App in Architecture (IPr)
Computer Sciences
255-Compter Graphics Applications (IPr)
304 Digital Computer Architecture (IPr)
445 File Management & Data Base Systems (IPr)
445-Computer Graphics (IPr)
542 Information Processing (IPr)
Natural Resource Management
405-Applied Resource Analysis (RSr)

Other California Colleges & Universities

Cabrillo College, Aptos (77-78)
Geography
3A,B,C-Map Reading, Air Photo Interpretation, Remote Sensing (PI,RS)

California Institute of Technology, Pasadena (76-77)
Computer Science
142A,B,&C-Computer Modeling & Data Analysis (IPr)
289-Computer Graphics (IPr)
Geological & Planetary Sciences
101A Introduction to Planetary Science (RSr)
159-Planetary Atmospheres (RSr)
225-Planetary Research w/Spacecraft (RSr)
226 Observational Planetary Astronomy (RSr)

City College of San Francisco (77-78)
Engineering
196 Photogrammetry (PG)

Cogswell College, San Francisco (76-78)
Civil Engineering
216 Surveying III App of Photogrammetry (PG)

College of the Redwoods, Eureka
Engineering
1C-Plane Surveying (intro to photogrammetry) (PGr)
Forest Technology
82-Forest Photo Interpretation (PI)

College of San Mateo (78 79)
Engineering
19-Fundamentals of Photogrammetry (PG)

College of the Siskiyous, Weed (78 80)
Engineering
1A,B-Plane Surveying (Photogrammetry & Computers) (PGr,IPr)

Columbia Junior College (77-78)
Natural Resources
60 Aerial Photography & Map Interpretation (PI)

DeAnza College, Cupertino (77-78)
Data Processing
18-Intro to Real-Time, on line & interactive programming (IPr)
37-Computer Graphics (IPr)
Engineering
341-Infrared technology (RSr)

East Los Angeles College (77-78)
Environmental Studies
7-Intro to Environmental Geology (PIr)

El Camino College (78-79), Torrence
Geography
3-Intro to Geographic Techniques (PIr)

Evergreen Valley College, San Jose (76-77)
Geology
10L-Physical Geology Laboratory (PIr)

Feather River College, Quincy (77-78)
Forestry
57-Map & Aerial Photo Interpretation (PI)

Foothill College (76 77) Los Altos Hills
Geology
14-Map Reading and Photo Interpretation (PI)
Planetary Geology (RSr)

Fresno City College (77-78)
Engineering
2-Engineering Plans and Topographic Mapping (PGr,PIr)

Fullerton College (77 78)
Civil Engineering
2 Aerial Photo Interpretation (PI)
Dept of Earth Sciences
Planetary Geology (RSr)

Lassen Community College, Susanville (77-78)
Forestry
VF 54 Map & Photo Interpretation I (PI)
TF 64-Map & Photo Interpretation II (PI)

Merced College (77-78)
Engineering
1B-Plane Surveying intro to Photogrammetry (PGr)
36B Plane Surveying (PGr)
Geology
1L-Physical Geology Lab (PIr)
Geography
1L-Physical Geography Lab (PIr)

Modesto Junior College (78-79)
Natural Resources
224-Mapping & Photo Interpretation (PI)

Napa College (76-77)
Geology
2-Physical Geology Lab (PIr)

Palomar College, San Marcos (77-78)
Geography
4-Map Reading & Interpretation (PI)

Pasadena City College (78)
Geology (Physical Science Dept)
Earth Science in the Laboratory (PIr)
Dept of Eng & Tech
170 Photogrammetry (PG)

Pierce College, Los Angeles (77-78)
Computer Science
48-Data Bases (IPr)
Geography
6-Intro to Geographical Analysis (IPr)
Geology
6-Physical Geology Lab (PIr)
22-Geomorphology (PIr)

Pomona College (77-78)
Geology
150-Planetary Geology (PIr)

Reedley College, (77-78)
Geology
12-Physical Geology Lab (PIr)

San Bernardino Valley College (77-78)
Engineering
216-217-Photogrammetry (PG)
Geography
134-Remote Sensing of the Environment (RS)
136-137 Photogrammetry (PG)

Santa Ana College (77-78)
Engineering
248-Engineering Photogrammetry (PG)

West Los Angeles College, Culver City (77-78)
Geography
4 Map Reading & Interpretation (PIr,PGr)

Santa Monica College (76-77)
Geography
4 Map Reading & Aerial Photo Interpretation (PI)

Santa Rosa Junior College (77-79)
Civil Engineering
50A,B-Plane Surveying (PGr)
52-Photogrammetry (PG)
53-Route Surveying and Design (PIr)
Forest Technology
76-Forest Photo Interpretation (PI)
Geography
53-Map and Air Photo Interpretation (PI)

Sierra College, Rocklin (78-79)
Drafting Technology
60A,B Mapping & Photogrammetry I & II (PG)
Engineering
60A,B-Mapping & Photogrammetry I & II (PG)

Stanford University (78-79)
Offers Masters degree core program in Remote Sensing
Geology
221-Photogeology (PIr)
Applied Earth Sciences
296-Airborne Exploration Structural Mapping (PGr)
297-Airborne Exploration-Lithologic Mapping (PGr)
192-Geomathematics I-Computer Applications in Geology and Applied Earth Sciences (IPr)
133-Remote Sensing of the Environment (IPr)
130 to 132-Environmental Earth Science I, II, III (RS)
295 A,B,C-Seminar Remote Sensing in Exploration (PIr)
Statistics
110-Statistical Methods in Engineering and Physical Science (IRr)
119-Statistical Inferences (IPr)
180 Statistical Computing Packages (IPr)
Geophysics
280-Data Analysis (IPr)
Environmental Engineering
263-Digital Filtering (IPr)
278-Intro to Statistical Signal Processing (IPr)
Geology
103A,B-Advanced Field Geology (PIr)
Food Research Inst
130-App of Programming to Agricultural Systems (IPr)

University of Redlands (77-78)
Geology
128-Remote Sensing (RS)

University of San Francisco (76 78)
Computer Science
169-Interactive Computer Graphics (IPr)

University of Southern California Graduate School (77-78)
Geological Sciences
528-Seminar in Remote Sensing (RS)
Civil Engineering
513L-Instrumental Methods for Environmental Analysis (PIr)

Ventura College (76-77)
Engineering
5B-Engineering Surveys (PGr)
Geology
2L-Physical Geology Lab (PIr)
Remote Sensing for Earth Scientists (RS)

West Coast University, Los Angeles (76-77)
Computer Sciences
313-Computer Graphics (IPr)
Graduate Program in Environmental Systems Methodology (IPr)

West Valley College, Saratoga (76-77)
Engineering
36C-Data Analysis (IPr)
1B-Plane Surveying (PGr)

SECTION V — PROGRAMS AND ACTIVITIES RELATED TO REMOTE SENSING

U.S. GEOLOGICAL SURVEY IN CALIFORNIA

U.S.G.S. Western Region

The U.S. Geological Survey, an agency of the Department of the Interior, has its national headquarters in Reston, Virginia To facilitate its work in the states of Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, Washington, and the Trust Territories of the Pacific, the Survey maintains a Western Region Headquarters in Menlo Park, California

The Geological Survey is organized into seven divisions The Topographic, Geologic, Water Resources, and Conservation Divisions are the primary operating units. In addition, an office of Land Information and Analysis directs and coordinates the multidisciplinary land resource and environmental analysis programs of the Survey.

Components of all Divisions operate within the Western Region and each maintains a headquarters staff at Menlo Park The Office of Land Information and Analysis, though headquartered in Reston, Virginia, carries on selected activities within the Western Region.

Remote Sensing Applications

In each of the major U S.G.S divisions, remote sensing plays a role. Aerial photography, from both high and low altitude aircraft, is still the most valuable remote sensing tool that the Survey uses, but the U S.G S. has been researching the applications of Landsat since Landsat-1 (ERTS) was launched

Although there has been considerable use of Landsat imagery and image analysis by the Geologic and Water Resources Divisions of the Western Region, only the Geography Program, within the office of Land Information and Analysis, is exploring ways to use Landsat digital data The work falls under the Research and Analysis branch of the Geography Program and focuses on Landsat applications useful to the National Land Use Mapping Program.

No other group in the Western Region is as involved with computer processing of Landsat data as this branch.

NCIC

Under the Topographic Division is the National Cartographic Information Center (NCIC). NCIC was established to provide a national information service to make cartographic data of the United States more easily accessible to the public and to various Federal, State, and local agencies Cartographic data include maps and charts, aerial photography, geodetic control data, and map data in digital form

There is an NCIC office in California at the U S G S Western Region

NCIC — Western Region
U S G S , 345 Middlefield Road
Menlo Park, CA 94025
(415) 323-2427

By requesting an Aerial Photography Summary Record System, Catalog 2, the user can have information on where, when, at what scale, and by what agency aerial photography (in California) was flown or will be flown

Data is cataloged of the following agencies

— U S. Dept of Agriculture
  Agricultural Stabilization and Conservation Service

— U S. Department of Agriculture
  Forest Service

— U S Geological Survey

— Bureau of Land Management

— NOAA, National Ocean Survey

— Aerial Map Industries

— United States

— U S. Air Force

— National Aeronautics and Space Administration (NASA)

Land Information and Analysis Office

To facilitate the solution of problems related to land use the Survey has established the Land Information and Analysis (LIA) Office This Office, based in Reston, Virginia, directs five major program efforts which include 1) the EROS (Earth Resources Observation Systems) Program, 2) the Geography Program, 3) the Earth Sciences Applications Program, 4) the Resource and Land Investigations Program; and 5) the Environmental Impact Analysis Program

Of the major divisions within the Survey, Land Information and Analysis relies most heavily on remote sensing tools and skills

EROS Program

An EROS Applications Assistance Facility is located at Menlo Park which is designed to help people gain access to the vast quantities of satellite and aircraft imagery stored at the EROS Data Center in Sioux Falls, South Dakota The EROS Data Center has the largest single collection of imagery of all the Federal agencies The Program's main objective is to facilitate the use and application of satellite imagery and data and aircraft photography to solve land and resource problems

EROS Applications Assistance
U S Geological Survey
Room 202, Building #3
345 Middlefield Road
Menlo Park, CA 94025
(415) 323-2727

Geography Program

The principal activity of the Geography Program is the compilation and interpretation of Land Use/Land Cover maps for the entire United States at a scale of 1 250,000 These maps have been produced almost exclusively with high altitude (U-2) color infrared photography.

The Geography Program in the Western Region is currently completing the northwestern California maps, Santa Rosa to Weed, in this series Southern California land use/land cover maps are available, and the maps for the central section of California, the San Francisco-San Luis Obispo area, are close to publication. All maps are available through the NCIC office at Menlo Park

Eugene Napier
U.S G.S. Geography Program
345 Middlefield Road
Menlo Park, CA 94025

Research and Analysis Branch

Assisting the Compilation and Interpretation Branch of the Geography Program is the Research and Analysis Branch Under a cooperative arrangement with NASA, this Branch is located at the NASA Ames Research Center, Moffett Field, CA The main activity of this group is the exploration of ways to use Landsat digital data in the compilation of the National Land Use Maps

To complete the land use maps of northwestern California, Landsat data will be relied on to differentiate evergreen trees from deciduous The interpretation will be done through the computer rather than by photo interpretation since these two types of trees are very difficult to separate on sight; however, the Research and Analysis Branch feels that by using a Landsat scene in late fall, they will be able to make the necessary distinctions

Since this Branch is located at NASA Ames Research Center, it often serves as a technical advisor for activities of the Western Regional Applications Program For example, they have worked with WRAP on the three state Pacific Northwest Demonstration Project and have cooperated on the remote sensing projects at Humboldt State University

Len Gaydos
U.S. Geological Survey
Mail Stop 240-8
NASA Ames Research Center
Moffett Field, CA 94035
(415) 965-6368

The Earth Sciences Applications Program

This program, under Land Information and Analysis, also relies heavily on remote sensing The program was designed to provide useful and timely scientific information for land-use planning decision making To accomplish this, the program has conducted three major urban area studies in the Western Region

The most extensive study is in the San Francisco Bay Region Maps have been prepared at a scale of 1 62,500 for the nine counties of the Bay area to show land use changes among nine categories of land use The San Francisco Bay area maps are part of the Survey's Census Cities Project and were derived primarily through interpretation of high altitude color infrared photographs, followed by a limited field check on the ground These maps are available through the NCIC office at Menlo Park

U.S. FOREST SERVICE REMOTE SENSING PROGRAM

National Program

The U S. Forest Service, over the years, has had many activities in remote sensing. Of particular use to the Service has been low and medium altitude black and white and color photography However, the Forest Service is beginning to expand its use of remote sensing tools to include high altitude infrared photography and satellite imagery

Realizing that remote sensing is becoming a valuable resource assessment and management tool, the U.S Forest Service, early in 1978, began a national program to set policies for the application of remote sensing technology The first step was the appointment of a national remote sensing coordinator. A Remote Sensing contract in each Forest Service Region has also been appointed so that a working network would be established throughout the country

Currently the national coordinator, Ray P. Allison, and his regional coordinators are determining what the requirements are for training and awareness in remote sensing within each Region Once these requirements are thoroughly understood, a national program can be initiated

Ray P. Allison
U S Forest Service
Remote Sensing Coordinator
P O Box 2417
Washington, DC 20013
(703) 235-2137

U-2 Optical Bar Camera Photo Project

As part of the Forest Service's remote sensing program, the agency is evaluating the usefulness of optical bar photography to locate areas of tree mortality Optical bar photography is taken with a panoramic camera at high altitudes High resolution color infrared film is used and the format of the optical bar is different from conventional framing camera imagery With the panoramic view angle, the sides (ends) of the pictures are a different scale than the center of the pictures Optical bar allows interpretation of features down to 3 to 4 feet

Although specialized equipment and techniques for viewing and mapping with this imagery exist and are semi-operational right now, the Forest Service is concentrating on the most basic concepts of simple steroscopic viewing and visual transfer of interpreted information from photo to map

The immediate use of the photography is for timber salvage planning and sales Foresters of Region 5, the State of California, are being trained in the interpretation of the photography so that they can evaluate its usefulness for finding and mapping aggregations of tree mortality and for marking timber salvage areas

U-2 flights with the optical bar have already been made over National Forest lands along the easten border of California and in the northwestern section of the State While the present focus is the tree mortality location potential, the Forest Service feels that the technology has many other applications for them and for other agencies Several specific optical bar evaluation projects in several disciplines are being formulated within Region 5 forests at this time

Alan Ambacher
U S Forest Service Region 5
Geometronics Division
Room 1406, Engineering Staff
630 Sansome Street
San Francisco, CA 94111
(415) 556-7527

CALIFORNIA ENVIRONMENTAL DATA CENTER

The California Environmental Data Center (EDC) was established by the Office of Planning and Research in March of 1978 to provide a focal point for coordination assistance to state, local, and federal agencies in their natural resource data gathering efforts Although called the "Environmental" Data Center, EDC is interested in the broad spectrum of natural resource/land use/agricultural data and seeks to serve all those who need such information

Cataloging California Agency Data

The EDC, above all, is establishing a network responsive to those who wish to use it. To do this, the Center has begun a comprehensive indexing and reference service for natural resources data at the local, state, and federal levels This service will form the core of the Center's activities By building on the data which currently exists in California, the EDC hopes to improve data collection in the state and increase the data's usefulness to those who must set state policy

Cataloging the information state agencies now hold is the first step. Seventeen state agencies have agreed to participate in an Interagency Advisory Committee on Data Cataloging Their committment to creating a network and to the work involved in the cataloging provides a solid basis for improving the availability of information The catalog will enable users to determine if needed information already exists or if it must be collected. This catalog will primarily list natural resources data, but will also index some other types of information used by the Resource Management agencies.

Surveying California Needs

A parallel program to inventory and catalog the data holdings of local agencies is underway The Environmental Data Center is working with counties, COGs, Regional Coastal Commissions, and selected municipalities to determine their needs for natural resources data and their current sources and adequacy of information

EDC is surveying the use of remote sensing techniques, kinds of information management systems employed, and the extent to which existing data meets current needs The results of this study will be published in Fall 1978 as a part of EDC's data cataloging and coordinating program.

Fall 1978 will also see the initiation of a program to determine the availability of data at all levels of government and in academia for a specific study region in the state This project will serve as a case study for the kinds of data which the EDC eventually hopes to index and catalog for the entire state Several state agencies have expressed interest in cooperating in this work and study areas are already under discussion

Coordination Activities

The Environmental Data Center is carrying out an extensive series of intergovernmental coordinating tasks The EDC is working with the Bureau of Land Management (BLM), Department of Agriculture/Forest Service, National Aeronautics and Space Administration (NASA), National Oceanic and

Atmospheric Administration (NOAA), and the U.S. Geological Survey/National Cartographic Information Center (USGS/NCIC) to tie together the natural resources data gathering and management efforts of federal and state agencies

The USDA is now informing the EDC of all planned aerial photography missions in California. This will enable other agencies in need of such photography to share in the cost of obtaining missions or to purchase prints of the film, rather than duplicate them with additional contracts.

The Bureau of Land Management is cooperating through data sharing and program coordination This cooperation may lead to further agreements between BLM and the state in the near future

The National Oceanic and Atmospheric Administration is preparing an Environmental Data Base Directory for California. The entry of state agency data files into the NOAA data base is coordinated through the EDC In return, any of the agencies may utilize NOAA's Data Base

NASA is coordinating its remote sensing application projects in California through the EDC in order to ensure maximum technology transfer where feasible to government agencies A task force comprised of a broad spectrum of state and local entities chaired by the EDC, will review technology transfer feasibility questions

EDC is working with USGS in cooperation with the National Cartographic Information Center NCIC is charged with the inventory of all mapped data at federal and state levels The EDC is working closely with NCIC to assure that the inventory approaches are compatible

Newsletter

The Environmental Data Center publishes a monthly newsletter which is a useful communication link for a variety of natural resource data user. The newsletter provides brief overviews of data collection and analysis efforts around the state with name and phone number for further information Those utilizing the newsletter include the Governor's staff, legislators and their staffs, state, local, and federal program managers, universities, the private sector, and the general public

Those wishing to add their names to the newsletter mailing list should contact the EDC office

Sally Bay Cornwell, Project Director
Timothy Hays, Staff Analyst
Environmental Data Center
Office of Planning and Research
1400 Tenth Street
Sacramento, CA 95814
(916) 322-3784

The EDC Advisory Committee

The following is a list of California agencies serving on the Interagency Advisory Committee for the Environmental Data Center

Air Resources Board

California Coastal Commission

Department of Conservation

Department of Fish and Game

Department of Food and Agriculture

Department of Forestry

Department of Navigation and Ocean Development

Department of Parks and Recreation

Department of Transportation

Department of Water Resources

Energy Commission

Office of Emergency Services

Office of Planning and Research

Resources Agency

Solid Waste Management Board

State Coastal Conservancy

State Lands Commission

State Water Resources Control Board

GEO-BASED INFORMATION SYSTEMS

Description

The most basic function of an inventory system is to provide a method for storing, retrieving and updating data When a comprehensive data base is in full use, it can provide the potential for reducing hundreds of man hours needed to produce reports on which management decisions are made It can greatly reduce the turn-around time necessary to address agency and environmental review procedures And it can save the user hundreds or thousands of dollars once the system is in full operation

A geo-based information system can be simple or sophisticated, depending upon the users' needs At its most sophisticated, such a system could have the capability to put any information that can be put on a map, into a computer The more sophisticated systems also provide a way to visually display much of the information in the system so that the user has both tabular and spatial data Computer-produced maps and/or tabulations are the usual output of the data manipulation process

Most geo-based information systems, like the Bay Area Spatial Information System, BASIS, are structured around an array of grid cells Each cell represents a land area of a certain size on the ground (one hectare or 2.5 acres for BASIS) and corresponds with a unit of computer storage The unit contains data codes representing the characteristics of that cell

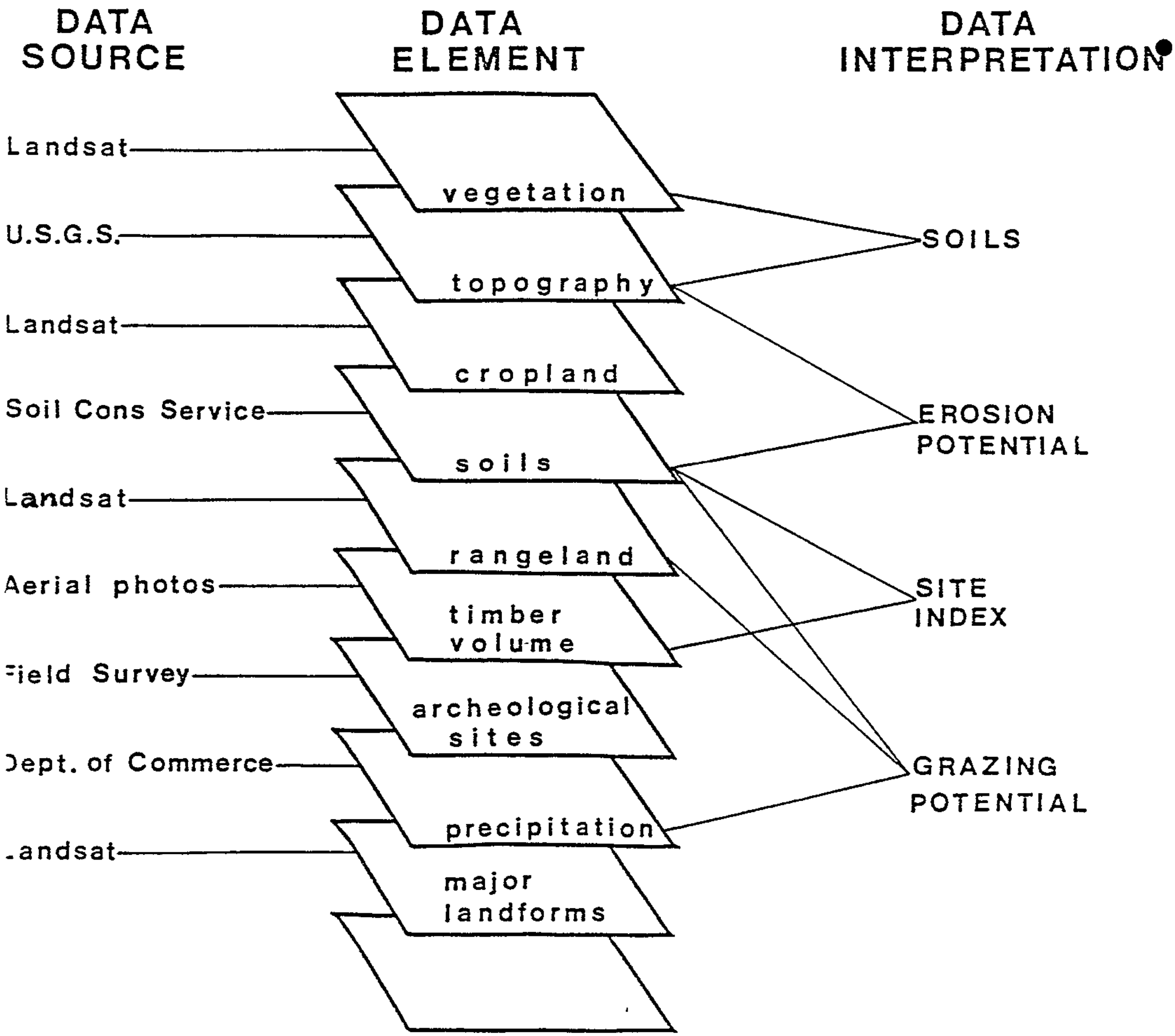
Many information systems can also work with data contained within polygons or irregularly-shaped areas Polygonal displays and analyses provide flexibility in the system and reflect, more closely than grid cells, the real boundaries of features on the ground

Some geo-based systems not only store, retrieve and update data, but also interpret or "model" second and third level information from original source data With this modelling, such a system permits the user to address subjective elements in a logical and consistent manner. It also enables the user to enter an unlimited number of factors into a decision matrix, explore all the options and reach a complete decision

Use of Remote Sensing

Remotely sensed data can definitely be incorporated into geo-based information systems Information from aerial photographs complements on-the-ground observations and can be manually digitized and placed in the computer system Landsat data is even more adaptive to geo-based information systems since Landsat data is also stored in grid cells and is available on computer-compatible tapes

Satellite imagery is becoming an increasingly useful tool as classification, registration, and enhancement techniques continue With a 1 1 acre resolution, Landsat satellites provide the overview for large area inventorying Landsat's greatest advantages at present for incorporation in data bases are the low cost of satellite imagery and computer-compatible tapes, their ongoing availability,

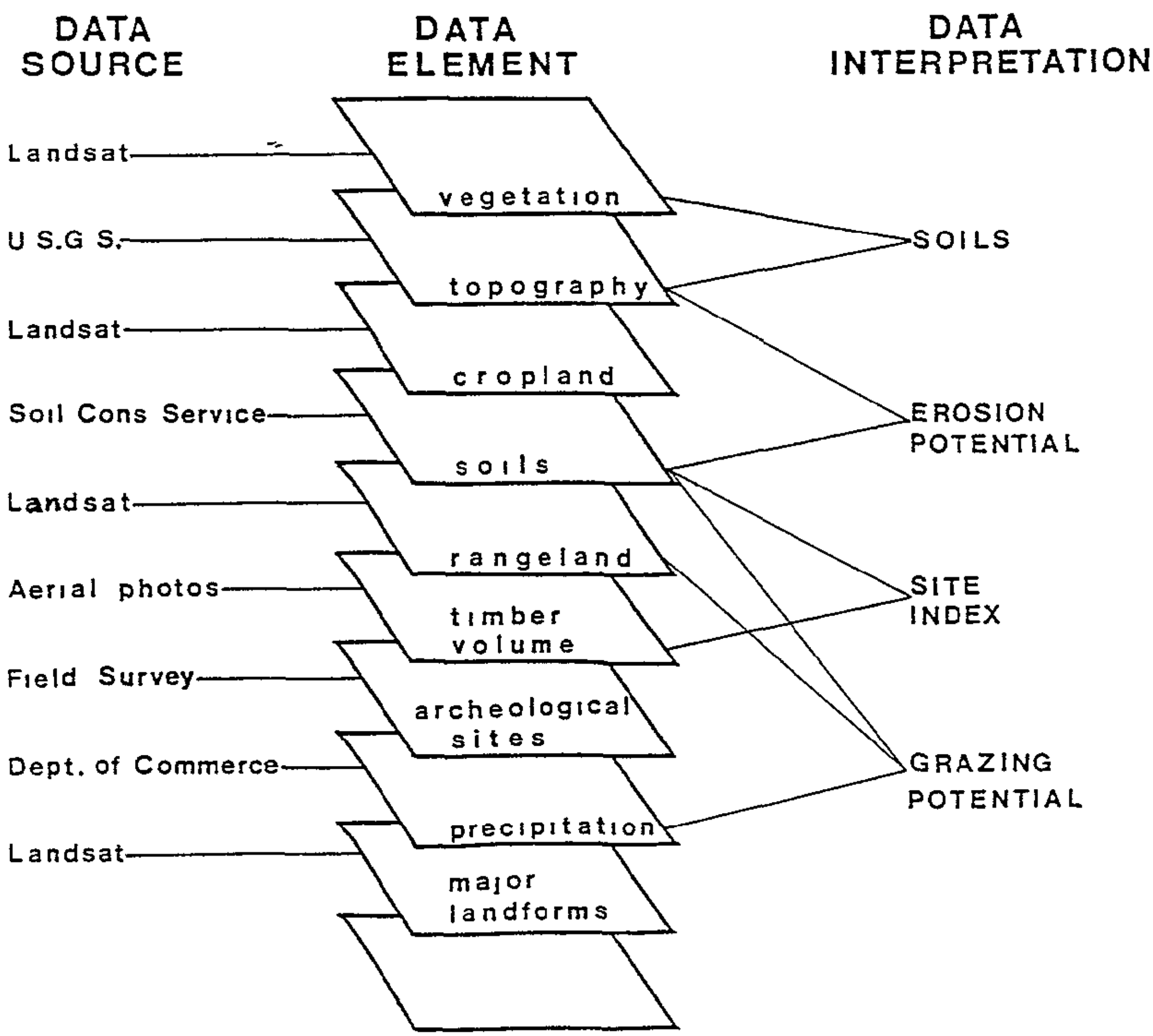

DATA SOURCE
DATA ELEMENT
DATA INTERPRETATION
Landsat
U.S.G.S.
Landsat
Soil Cons Service
Landsat
Aerial photos
Field Survey
Dept. of Commerce
Landsat
vegetation
topography
cropland
soils
rangeland
timber volume
archeological sites
precipitation
major landforms
SOILS
EROSION POTENTIAL
SITE INDEX
GRAZING POTENTIAL

and the convenience of processing, entering and storing data within the same computer system.

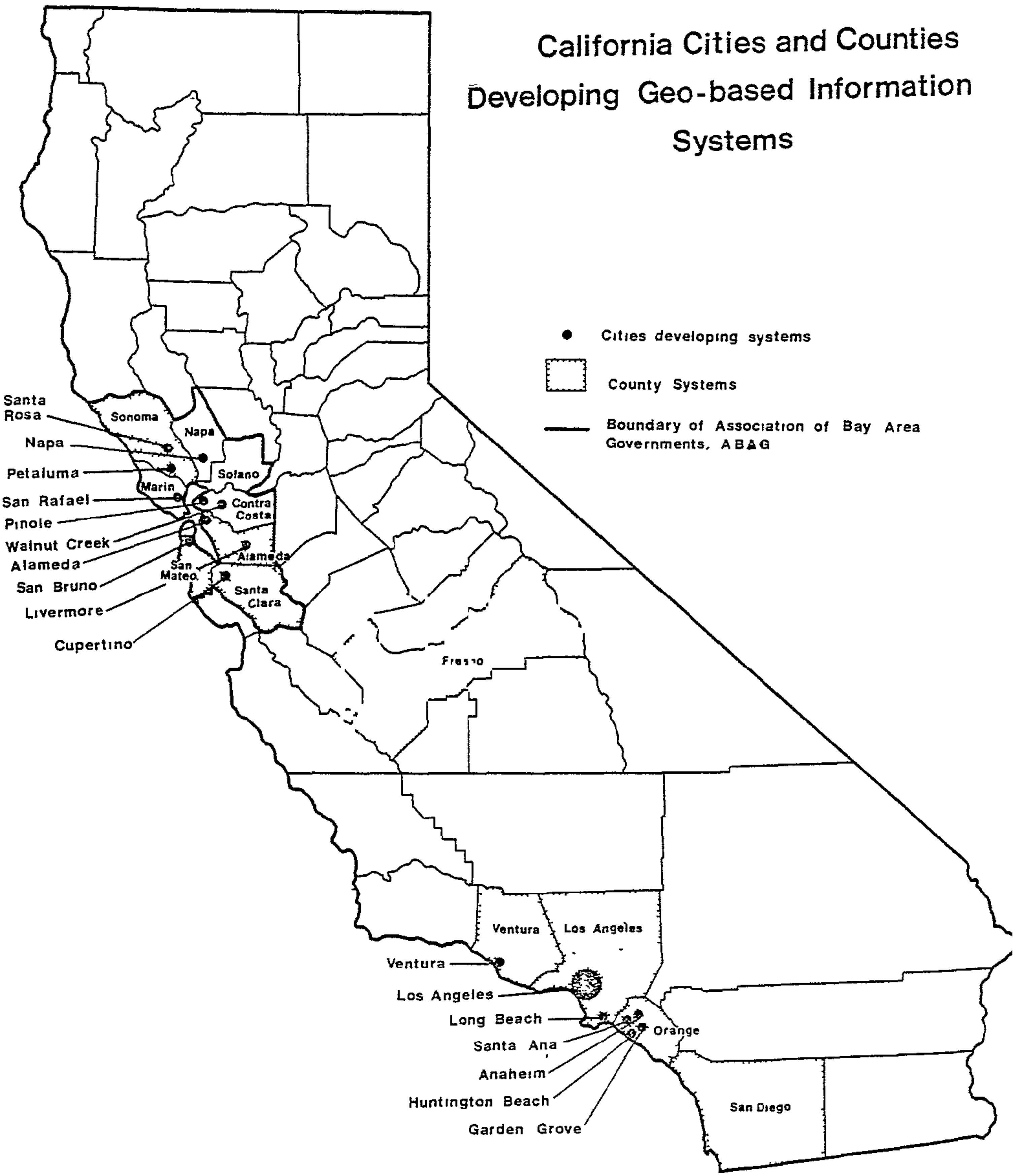
In 1980, a new Landsat, Landsat-D, will be launched with potential resolution capabilities of 30 meters If this is achieved, many planners feel the satellite series will be an even more powerful inventory aid than it is today

Types of Data

Here is a graphic example of the types of data that may be contained in an information system Each system, however, will be different because of the different physical concerns of each city, county, company, or large geographic area



A geo-based information system has great advantages for its users It can provide a method of integrating a wide variety of information, both tabular data and spatial images, into the decision-making process When used to its fullest and updated regularly, such a system can eliminate job duplication and ensure prompt responses to the user's problems And a computerized data base may be the ony way to manipulate the large volume of data needed for answering state and local government's needs


California Cities and Counties Developing Geo-based Information Systems
Cities developing systems
County Systems
Boundary of Association of Bay Area Governments, ABAG
Santa Rosa
Napa
Petaluma
San Rafael
Pinole
Walnut Creek
Alameda
San Bruno
Livermore
Cupertino
Sonoma
Napa
Solano
Marin
Contra Costa
Alameda
San Mateo
Santa Clara
Fresno
Ventura
Los Angeles
Ventura
Los Angeles
Long Beach
Santa Ana
Anaheim
Huntington Beach
Garden Grove
Orange
San Diego

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California Counties Developing Geo-based Information Systems

The counties are listed in alphabetical order with a brief description of the system and a contact person, if either was available to the survey

Also listed under the counties is a partial listing of publications on their information systems. The majority of this list was compiled by the Tacoma, Washington, Planning Department for a March 1977 publication on Geo-Based Information Systems in the United States.

Alameda County

Working with Comarc Design Systems, 315 Bay Street, San Francisco, CA 94133 (415) 392-5300

Fresno County

The Fresno Council of Governments is working with Comarc Design Systems to develop a geo-based information system for the county

Publications

Environmental Management Information System, the Fresno County Planning Information System Project — The First Year Resources Requirements and Prospects (no date)

Geographic Oriented Information Systems — David C. McElroy, Information Industry Consultant. (4/76)

Orange County

Developing a Land Use Information System for the county, using 1980 Census tracts. 800 mile-squared area, 25 cities with 69 community analysis areas The final product will include 58 categories of land use

Tom Tousignant, County Forecast Cost and Analysis,
515 N Sycamore, Santa Ana, CA 92701 (714) 834-5597

Publications

County of Orange, LR/UDS (1976)

Orange County Environmental Management Agency, Environmental Planning & Management System — Requirements Specification (4/76)

San Diego County

Since 1971 the county has been developing a Regional Planning Information System The planning program falls under the Comprehensive Planning Organization of the San Diego Region (CPO) System includes 1) Planning Model Systems, 2) General Support System, and 3) Basic Data Systems Some of the major Basic Data System components are base maps, land use, population and housing, employment, and census

Ross Hall, Comprehensive Planning Organization of the San Diego Region, Security Pacific Plaza, Suite 524, 1200 Third Avenue, San Diego, CA 92101 (714) 233-5211

Publications

Regional Transportation Plan; Development of the Plan, Volume III Comprehensive Planning Organization (3/75)
Incidence Maps CPO (1976)
Managing Urban Growth and Public Facilities. CPO (7/76)
Facilities Planning Made Simple CPO. (7/78)

San Mateo County

The county is cooperating with the U S. Geological Survey Geography Program, Reston, Virginia, to develop Level III Land Use classifications for the entire county, as part of the National Land Use Mapping Program Land use information will be available in both map and tabular form

James Anderson, Chief Geographer, U.S. Geological Survey, National Center, 12201 Sunrise Valley Drive, Reston, VA 22092 (703) 860-6344

Santa Clara County

Developing a system with Comarc Design Systems, San Francisco

Publications

A Man-made System for Aiding Local Government in Police Formulation and Evaluation. E J Cristiani, et al. IBM (3/72)

Sonoma County

Developing a geo-based information system with Comarc Design Systems.

Ventura County

The county is developing a Decision-Oriented Resource Information System (DORIS) under a grant from NASA to the Geography Remote Sensing Unit, UC Santa Barbara The information, which is being developed around seven and a half minute quad maps, will include (but not be limited to): vegetation, soils, geology; land elevation, slope and aspect; biological habitat and flood plain boundaries

Under an additional NASA grant, the county and UC Santa Barbara will produce sequel guidelines for updating the information system These procedures will be available to other counties when completed.

Robert Faulk, Ventura County Flood Control, 597 E Main Street, Ventura, CA 93001 (805) 654-2036

Government Associations Developing Geo-Based Information Systems

The Fresno Council of Governments and the Comprehensive Planning Organization of the San Diego Region represent government associations working on geo-based information systems However, since their activities are centered in one county, they have been included under the County Section

ABAG

In California there is only one multiple-county geo-based information system being developed It is called BASIS, the Bay Area Spatial Information System, and has been developed since 1976 by the Association of Bay Area Governments, ABAG

BASIS covers the nine-county Bay region and has been designed to provide more detailed and timely data for regional and local planning The system currently contains the following types of data· earthquake faults, ocean and bay coastlines, precipitation, geologic materials, flood prone areas, slope stability, well yield, prime agricultural land, erosion, Bay depth contours, airports, seaports, vacant industrial sites, 1970 Census tracts, and county boundaries

Other types of data, e g. land use, public land ownership and freeway intersections, are being acquired and encoded as they become available

Paul Wilson or Don Olmstead, Association of Bay Area Governments, Hotel Claremont, Berkeley, CA 94705 (415) 841-9730

Cities Developing Geo-Based Information Systems

The majority of the smaller cities listed in this section have the help of Comarc Design Systems in developing either all or parts of their systems Contacts have been included in this list if they were available, but no attempt has been made to describe each of these city systems

A partial publication list is also included that was compiled by the Tacoma, Washington, Planning Department for a March 1977 publication on Geo-Based Information Systems in the United States

City of Alameda. Comarc Design Systems

Cities of Anaheim, Garden Grove, Huntington Beach, Santa Ana (Four City Consortium

Publications

Geocoding Project Conceptualization. (9/75)

Geocoding System Design (10/75)

City of Cupertino Comarc Design Systems

City of Livermore Comarc Design Systems

City of Long Beach.

Publications

Investigation Support at the City of Long Beach IBM (10/73)

City of Los Angeles.

Initial Land Use Planning and Management System designed by Environmental Systems Research Institute, 380 New York Street, Redlands, CA 92373 (714) 793-2853

Calvin S Hamilton, Director of Planning, Department of City Planning, Room 561-C, City Hall, Los Angeles, CA (213) 485-5073

Publications

An Introduction to the L A Land Use Planning and Management of Subsystem (LUMPAMS) (1/75)

Catalogue of Computer Print Outs — Data on the City of L A (2/75)

Citywide Parcel Information System — Systems Design and Operations Manual (11/74)
L A. City Planning Department Urban Data Base Index (7/74)
Review & Evaluation of Math-Model Development Program. (no date)
Technological Tools & Data Resources Available as Input the Planning Process (1/74)
Use of the Grid-Based Information System for Centers Definition (12/74)

City of Napa. Comarc Design Systems

City of Pinole Comarc Design Systems.

City of Petaluma Comarc Design Systems

City of San Francisco.
Publications
Project CABLE — Geographic Subsystem (4/72)

City of San Jose
Publications
Fire Alarm Assignment System—Executive Summary Stanley Phillips, San Jose Fire Department (9/76)

City of San Rafael Comarc Design Systems

City of Santa Rosa. Comarc Design Systems.
Nancy Hamilton Blank, Department of Community Development, City Hall, P O Box 1678, Santa Rosa, CA 95402

City of Ventura. Comarc Design Systems

City of Walnut Creek. Comarc Design Systems

Private Industry in California Developing Geo-Based Information Systems

Pacific Gas and Electric Company

The ony private industry that has furnished the survey with detailed information on the development of its environmental data system is the Pacific Gas and Electric Company This system has been developed by the Urban and Regional Planning section of the Land Department

Since the Company's service territory covers some 94,000 square miles in California—from Shasta to Kern counties—P G &E felt it was imperative to develop some form of a computerized system for the management, retrieval and analysis of data on the environment of the service area At the present time the data base covers 22,000 square miles

Five major types of data are stored in the system 1) terrain units, 2) special features, including endangered species, historic sites, and ecologically sensitive zones, 3) land use, 4) ridges, courses and fault lines, and 5) infrastructure, such as highways, railroads, transmission lines, etc

JoAnn R. Effron, Land Use Planner, Pacific Gas and Electric Company, 77 Beale Street, San Francisco, CA 94106 (415) 781-4211

Other Companies

The following is a list of other private industries developing geo-based information systems All of them are working with Comarc Design Systems Neither addresses nor contacts are included in this list

Georgia Pacific Corporation
Bechtel Corporation
St Regis Corporation
Kimberly-Clark Corporation
Kaiser Engineering Inc
Simpson Timber Company
Pacific Telephone & Telegraph Company
Arcata National Corporation
Woodward-Clyde Consultants
Trans America Engineering Inc

COMMUNICATION SATELLITES AND CALIFORNIA

CTS and Remote Sensing

Although there are both operational and experimental uses of communication satellites in California, there has been little use of these satellites for environmental or remote sensing-related purposes

In states such as Florida, communication satellites have acted as relays for environmental data obtained by remote sensor platforms on the ground In California, projects that need data relayed from remote areas, at present, use the GOES satellite system (Section II, Weather Satellite Users)

Instead, communication satellites have been used in the state to teleconference discussions on natural resources and environmental issues

Mobile Analysis and Telecommunication Experiment (MATE)

One exception to the general use of communication satellites was the Mobile Analysis and Telecommunication Experiment, MATE, designed at NASA Ames Research Center, Moffett Field, California

For this experiment, a van was equipped with a small computer system to display Landsat satellite data Since the storage capacity of the computer in the van was small and the amount of Landsat data to process of any given area, great, the Communication Technology Satellite, CTS, was used as a one-way relay of Landsat data from NASA Ames Research Center to the mobile van

MATE was testing the use of remote display terminals at various locations, interacting with a Landsat image processing computer at a central location, in this case, NASA Ames

Unfortunately, before the van could be tested to any degree it caught fire and was totally destroyed. Funds are now being sought for a second MATE.

Teleconferences on Remote Sensing

In March and April 1978, there were two teleconferences originating from NASA Ames Research Center that focused on remote sensing technology

The WRAP Program

The first in March was an interview with Dr Anthony Calio, NASA Applications Branch Chief, and Mr Floyd Roberson, NASA Technology Transfer head Both men were interviewed by members of the Western Regional Applications Program (WRAP), located at NASA Ames and by a member of the Remote Sensing Project at Humboldt State University, Arcata, California The discussion centered around the future of the Landsat program and the role of Regional Applications Programs in transferring remote sensing technology Dr Calio was of the opinion, at that time, that Applications could become the lead branch within NASA in the next few years

For excerpts of that interview, see Volume 1, No 1 of *Plain Brown Wrapper,* newsletter of the Western Regional Applications Program

American Indian Telecommunication Demonstration Project

The second teleconference on remote sensing applications was part of a three-day Indian Telecommunication Demonstration Project in April 1978 One aspect of the overall demonstration was the use of the communication satellite for higher education In particular, the participants were concerned about education in natural resources management and planning

On the second day of the project, Indians on the Crow Agency, Montana, and members of the All-Pueblo Council, New Mexico, viewed a videotape on the use of remote sensing tools to aid Indian natural resources management The videotape was sent from NASA Ames Research Center and was prepared by the Remote Sensing and Technology Transfer Project, Humboldt State University

This videotape is available on short-term loan Contact·

Kamila Plesmid
Remote Sensing Project
Schmidt House 90
Humboldt State University
Arcata, CA 95521
(707) 826-3112

Public Service Satellite Consortium

In late 1975 the Public Service Satellite Consortium, PSSC, was established as response to the growing national interest in developing public service uses for communication satellites PSSC began with seventy members representing the fields of education, health care, library services, public safety and government administration. Today that membership nears a hundred.

Although PSSC does not plan to launch a satellite itself, the Consortium has made arrangements with the Hughes Aircraft Company to develop a "practical public service satellite demonstration" on the Hughes Syncom IV, a test payload of NASA's Space Shuttle PSSC will define the communication requirements that will satisfy a broad spectrum of public service users

In 1977, under a NASA grant, PSSC found that these requirements are three-fold improved access, cost containment and maintenance of quality In the next few years the chief function of the consortium will be to bring together similar public service interests and design a coordinated, economical program of satellite communications to serve needs not adequately being met by conventional communications now

The principal office of the Consortium is located in San Diego, California

Polly Rash
Director of Communications
Public Service Satellite Consortium
4040 Sorrento Valley Blvd.
San Diego, CA 92121
(714) 452-1140

Consortium membership in California

The following California organizations are members of the Public Service Satellite Consortium, as of the November 1977 membership list

California Public Broadcasting Commission
California Innovation Group, Inc
California State University and Colleges
Community Television of Southern California, KCET
Modesto Junior College
San Diego County Department of Education
San Diego State University
Stanford University—Communications Satellite Planning Center
University of California
University of Southern California
Western Interstate Commission for Higher Education (WICHE)

For a complete membership list, contact Poly Rash at the PSSC principal office in San Diego

PSSC Satellite Demonstrations in California

In the first seven months of 1978, members of the Consortium conducted seven short-term demonstration projects in California. In addition to these projects, the PSSC supports the Veterans Administration in conducting a continuing medical education program via satellite to VA hospitals in the western half of the U S, including California.

Also, fourteen public television stations in California will begin to use WESTAR for receiving PBS programming in 1978 on a regular basis

Proposal for Statewide Use of Communication Satellites

In 1977-78, part of Governor Jerry Brown's program was to invest in the regular use of satellites for communication in California The plan was to acquire hardware for limited operation on the CTS satellite and then follow-up with a statewide program using Syncom IV, after it was launched in 1980 or 1981

The program envisioned both fixed and portable terminals as well as two-way interactive video equipment There were also provisions for two-way voice terminals to be used in emergency situations such as forest fires, earthquakes, floods, or other disasters

The major uses of such a statewide system would be teleconferencing and education, with additional experimental activities in rural health services and data transfer between computers

The passage of Proposition 13 in June 1978, however, has created a "no frills" environment in the California legislature Consequently, the Governor's program to use satellites for communication will not be funded this year

APPENDIX

Selected Publications

References and Credits

Sample Survey Form

400

LIST OF SELECTED PUBLICATIONS

(By Discipline)

1974 - Present

Provided by the
Remote Sensing Research Program
Space Sciences Laboratory, and
Department of Forestry and Conservation
University of California, Berkeley

AGRICULTURE

Benson, A S. and R N Colwell 1975 Agricultural Interpretation Technique Development. Remote Sensing Research Program, Space Sciences Labor- Series 16, Issue 77 (University of California, Berkeley), 248 pp

Benson, A.S and R.N Colwell. 1974 Regional Agricultural Surveys Using ERTS-1 Data Remote Sensing Research Program, Space Sciences Laboratory Series 16, Issue 50 (University of California, Berkeley), 192 pp

Hay, C M , R W Thomas, A.S Benson, and R.N Colwell. 1977 Development of Techniques for Producing Static Strata Maps and Development of Photo-interpretive Methods Based on Multitemporal Landsat Data Remote Sensing Research Program, Space Sciences Laboratory Series 18, Issues 2, 28, 60 (University of California, Berkeley)

Hay, C M., R W Thomas, and R.N. Colwell, 1976 Application of Photointerpretive Techniques to Wheat Identification, Signature Extension, and Sampling Strategy Remote Sensing Research Program, Space Sciences Laboratory Series 17, Issue 33 (University of California, Berkeley)

Hay, C M 1974 Agricultural Inventory Techniques with Orbital and High Altitude Imagery *Photogrammetric Engineering* 60 (11) 1283-1293.

Hay, C M 1974 Agricultural Inventory Techniques Using Sequential High Altitude Photography Remote Sensing Research Program (University of California, Berkeley)

Thomas, R W and C M. Hay 1977 Two Phase Sampling for Wheat Acreage Estimation *Proceedings,* 11th International Symposium on Remote Sensing of Environment, pp 909-918.

Thomas, R W , C M Hay, C E. Brown, J D Nichols, and D Noren 1975 A Remote Sensing-Aided Small Grains Inventory Using Sequential Landsat Imagery *Proceedings,* ASP Fall Convention, pp. 298-314

Wall, S L and R N Colwell 1977 Determining the Usefulness of Remote Sensing for Estimating Agricultural Water Demand in California Remote Sensing Research Program, Space Sciences' Laboratory Series 18, Issue 59 (University of California, Berkeley), 66 pp

Wall, S L. and R N Colwell 1975 Inventory of Irrigated Lands for Selected

Counties Within the State of California Based on Landsat and Supporting Aircraft Data Remote Sensing Research Program, Space Sciences Laboratory Series 18, Issue 50 (University of California, Berkeley), 52 pp

DATA PROCESSING/ANALYSIS

Colwell, R N. and E.F Katibah. 1976 Optical vs Electronic Enhancement of Remote Sensing Imagery *Proceedings,* Society of Photo Optical Instrumentation Engineers, Vol 74, pp 111-118

Jones, N A , J D Nichols, F.G Harvey, P R. Ritter, and M J Gialdini 1975 Software for Geometrical Transformation of Digital Data Used for Remote Sensing Applications. Presented at Symposium on Machine Processing of Remotely Sensed Data, LARS-Purdue University

Katibah, E F. 1975 The Photographic Construction of Landsat Color Composite Imagery Remote Sensing Research Program Information Note (University of California, Berkeley)

Nichols, J D and W Senkus 1975 Combined Sequential Analysis of Multiple Features *Proceedings,* Symposium on Machine Processing of Remotely Sensed Data, LARS-Purdue University, pp 1A-28

Nichols, J.D and W Senkus. 1973 Combining Human and Computer Interpretation Capabilities to Analyze ERTS Imagery Presented at Symposium on Machine Processing of Remotely Sensed Data, LARS-Purdue University

Steele, R S , W Senkus, I Flores, G Vasick, and J D Nichols 1975 A Color Display Terminal System for Interactive Image Analysis *Proceedings,* 10th International Symposium on Remote Sensing of Environment, pp. 777-782

Steele, R S , I Flores, P.R Ritter, J D Nichols, M J Gialdini, and W Snekus 1975 A Four-Channel Optical Film Annotator for Production of Planimetrically Correct Images *Proceedings,* Symposium on Machine Processing of Remotely Sensed Data, LARS-Purdue University, pp 3A-39

Thomas R W. 1974 Construction of a Doubly Unaligned Systematic Double Sample with Unweighted Regression Remote Sensing Research Program, Space Sciences Laboratory Series 15, Issue 34 (University of California, Berkeley), 31 pp

Thomas, R W 1975 The Use of the Analysis of Covariance Model in Spatial Point Estimation *Proceedings,* Symposium on Machine Processing of Remotely Sensed Data, LARS-Purdue University

Thomas, R W and G Vassick 1975 Application of the Scheffe' Method of Multiple Comparison to Determination of Class Separability *Proceedings,* Symposium on Machine Processing of Remotely Sensed Data, LARS-Purdue University

HYDROLOGY

Katibah, E F. 1975 Estimation of Areal Extent of Snow with ERTS Satellite Data

Thesis, Master of Science Dergree (Wildland Resource Science, University of California, Berkeley)

Katibah, E F 1975 Areal Extent of Snow Estimation in the Northern Sierra Nevada Mountains Using Landsat-1 Imagery *Proceedings,* Earth Resources Survey Symposium (Houston, Texas), pp. 2621-2643

Katibah, E.F 1975. Operational Use of Landsat Imagery for the Estimation of Snow Areal Extent Presented at Operational Applications of Satellite Snowcover Observations Meeting NASA and the University of Nevada at Reno (Sough Lake Tahoe, California)

Khorram, S and E F Katibah 1978 Use of Landsat-1 and NOAA-4 Data for Evapotranspiration Estimation Over the Middle Fork of the Feather River Watershed. *Proceedings,* American Society of Photogrammetry Annual Meeting (Washington, D.C)

Khorram, S 1977 Use of Multispectral Imagery in Estimating Snow Areal Extent and Snow Water Content Cost-Effectively. *Proceedings,* Symposium on Machine Processing of Remotely Sensed Data, LARS-Purdue University, 10 pp

Khorram, S. 1977 Remote Sensing-Aided Systems for Snow Quantification, Evapotranspiration Estimation, and Their Application in Hydrologic Models. *Proceedings,* 11th International Symposium on Remote Sensing of Environment pp 795-806.

Khorram, S 1977. A Solar Energy Estimation Procedure Using Remote Sensing Techniques. *Proceedings,* Remote Sensing of Earth Resources Conference, The University of Tennessee Space Institute (Tullahoma, Tennessee), 20 pp.

Khorram, S 1977 An Information System Design for Watershed-Wide Modeling of Water Loss to the Atmosphere Using Remote Sensing Techniques *Proceedings,* American Society of Photogrammetry, Annual Meeting (Washington, D C), pp 517-537

Khorram, S 1976 Remote Sensing-Aided Information System Design for Water Resources Mangement, *Proceedings,* Earth Science Symposium, U S Forest Service (Fresno, California), 15 pp

Khorram, S and R N Colwell. 1976 Remote Sensing-Aided Procedure for Water Yield Estimation Chapter 2B *In* An Integrated Study of Earth Resources in the State of California Using Remote Sensing Techniques, Space Sciences Laboratory Series 17, Issue 69 (University of California, Berkeley), 108 pp

Khorram, S and R W Thomas 1976 A Remote Sensing-Aided System for Watershed-Wide Evapotranspiration Estimation *Proceedings,* Joint Scientific Meeting on Mountain Meteorology and Biometeorology, Swiss Geophysical Society, Swiss Society of Balneology and Bioclimatology, and American Meteorological Society (Interlaken, Switzerland), pp 42-60

Sharp, J M and R W Thomas 1975 A Cost-Effectiveness Comparison of Existing and Landsat-Aided Snow Water Content Estimation Systems *Proceedings,* 10th International Symposium on Remote Sensing of Environment, pp 1255-1262

Thomas, R W and S Khorram 1975 Remote Sensing-Aided Procedures for water Yield Estimation Chapter 2B *In* An Integrated Study of Earth Resources in the State of California Using Remote Sensing Techniques Remote Sensing Research Program, Space Sciences Laboratory Series 17, Issue 10 (University of California, Berkeley), 86 pp.

WILDLAND

Benson, A S and R N. Colwell 1977 Fuel Mapping in Relation to the Management of Brushlands and Timberlands in Mendocino County, California Chap. 2 *In* Application of Remote Sensing to Selected Problems Within the State of California Remote Sensing Research Program, Space Sciences Laboratory Series 19, Issue 5 (University of California, Berkeley), 137 pp

Carneggie, D M., S D DeGloria, and R N Colwell 1974 Determining Range Condition and Forage Production Potential in California from ERTS-1 Imagery *Proceedings,* 9th International Symposium on Remote Sensing of Environment

DeGloria, S D , S J. Daus, and R.W. Thomas 1975 The Utilization of Remote Sensing Data for a Multidisciplinary Resource Inventory and Analysis Within a Rangeland Environment *Proceedings,* ASP Fall Convention, pp 640-659

DeGloria, S D , S J. Daus, N Tosta, and K. Bonner 1975 Utilization of High Altitude Photography and Landsat-1 Data for Change Detection and Sensitive Area Analysis *Proceedings,* 10th International Symposium on Remote Sensing of Environment, pp 359-368.

Gialdini, J , S Titus, J Nichols, and R. Thomas. 1975 The Integration of Manual and Automatic Image Analysis Techniques with Supporting Ground Data in a Multistage Sampling Framework for Timber Resource Inventories Three Examples *Proceedings,* NASA Earth Resources Survey Symposium (Houston, Texas), Vol I-B, pp 1377-1378

Nichols, J D and R N Colwell. 1974 ERTS-1 Data as an Aid to Wildland Resource Management in Northern California Remote Sensing Research Program, Space Sciences Laboratory Series 16, Issue 62 (University of California, Berkeley), 472 pp

Thomas, R W , K G Bonner, S D DeGloria, and N Tosta 1977 Application of Multistage Sampling Procedures for Range Resource Quantification Paper presented at Society of Range Management, Annual Meeting (Portland, Oregon), 34 pp

Titus, S J , L C Wensel, and R N Colwell 1977 Development of Sampling Designs to Use with Remotely Sensed Data Remote Sensing Research Program, Department of Forestry and Conservation (University of California, Berkeley), 253 pp

Titus, S J and L.C. Wensel. 1977. Use of Multispectral Data in Design of Forest Sample Surveys *Proceedings,* 11th International Symposium on Remote Sensing of Environment, pp 505-513

Titus, S J., and R N. Colwell. 1976 Sam Houston National Forest Inventory and Development of a Survey Planning Model (FAP/TR) Remote Sensing Research Program, Space Sciences Laboratory Series 17, Issue 55 (University of California, Berkeley), 154 pp

Titus, S.J., M.J. Gialdini, and J.D Nichols 1975 A Total Timber Resource Inventory Based Upon Manual and Automated Analysis of Landsat-1 and Supporting Aircraft Data Using Stratified Multistage Sampling Techniques *Proceedings,* 10th International Symposium on Remote Sensing of Environment, pp. 1093-1099

Titus, S J. 1975. An Integrated System for Computer Processing of Landsat-1 Imagery, Large-Scale Photography and Ground Data to Produce Resource Inventory Estimates Based on Stratified Multistage Sampling Techniques. Paper presented at Symposium on Machine Processing of Remotely Sensed Data, LARS-Purdue University

Wall, S L and R N Colwell 1976 Recreational Analysis of River Basins Remote Sensing Research Program, Department of Forestry and Conservation (University of California, Berkeley), 106 pp

The following are selected publications of the Sociology Group by Dr. Ida Hoos covering the period 1976-1978

"Utilization of Remote Sensing Data—The Sociological Perspective" *Photogrammetric Engineering and Remote Sensing,* Vol 42(2) 201-210

"Problems in Futures Research", Chapter 11 in *The Study of the Future,* Washington, D C — National Science Foundation, Research Applications Directorate, RANN — Research Applied to National Needs (Division of Intergovernmental Science and Public Technology), NSF/RA-770036, August, 1977, pp 122-129

"Some Fallacies in Futures Research", *Technological Forecasting and Social Change,* Vol 10, no 4, 1977, pp 335-344

Chapter of *Systems Analysis in Public Policy* A Critique, appeared in the book *Systems Behaviour,* 2nd Edition (United Kingdom), editors John Beishon and Geoff Peters, Open University Press, Harper and Row Publishers, 1977

"OR/MS and the Management of Cities", *Interfaces,* Vol 7, no 2, February, 1977

"Societal Aspects of Technology Assessment," *Technological Forecasting and Social Change,* forthcoming, 1978

SELECTED REFERENCES AND CREDITS

Section I — Remote Sensing Technology

General Overview

Dr Floyd Sabins, *Remote Sensing, Principles and Interpretation,* W H Freeman and Company, San Francisco, 1978

Dr Lawrence Fox III, Forestry Department, School of Natural Resources, Humboldt State University, Arcata, CA

Remote Sensing in California — A History in Water Quality Control

Gilbert Fraga, State Water Resources Control Board, 2014 T Street, Sacramento, CA

Section II — California Remote Sensing Activities

Landsat Satellite Technology Transfer Program

Phoebe Williams, WRAP Summary Reports, Information Services, NASA Ames Research Center, Moffett Field, CA

Weather Satellite Users in California

Ernest Daghir, National Environmental Satellite Service (NESS), Redwood City, CA

William Innes, Senior Meteorologist, Progress Report, February 1978, "Fire Weather Data System," Region I, California Dept of Forestry, Sacramento, CA

Charles Howard, Snow Surveys Branch of Flood Management Division, California Dept of Water Resources, Sacramento, CA

Fred Jurick, Marine Advisory Service, Eureka, CA

Dr Michael Laurs, Albacore Tuna Investigation, Scripps Institute of Oceanography, La Jolla, CA

Donald Montgomery, Jet Propulsion Laboratory, Pasadena, CA

Dr Robert Berstein, Scripps Institute of Oceanography, La Jolla, CA

Specific Remote Sensing Projects, 1977-78

Maps Rendered by Genia Kungel, Arcata, CA and Mary Paradise, Eureka, CA

Summary Table by Cindy Abernathy, Arcata, CA

Section III — Industrial Involvement in Remote Sensing

Industry Providing Services and Products

Lowell H Brigham General Electric Corporation, Space Division, Beltsville, MD

"Image Analysis Services," *Landsat Data User Notes,* May 1978

"Ocean Data Resources," U S Government pamphlet 41-658, prepared for the Committee on Commerce, 1975

Industry Using Remote Sensing

Dr Floyd Sabins, *Remote Sensing, Principles and Interpretation,* W H Free-

man and Company, San Francisco, 1978.
Craig Gross, J G Boswell Company, Corcoran, CA
Comarc Design Systems Inc., 315 Bay Street, San Francisco, CA

Section IV — Colleges and Universities Teaching Remote Sensing

California college and university catalogs, Library, Humboldt State University, Arcata, CA
"Southern California Universities and Colleges Teaching Remote Sensing," from a paper presented by Len Bowden, UC Riverside, at Conference of Remote Sensing Educators, CORSE, June 1978.

Section V — Programs and Activities Related to Remote Sensing

U.S. Geological Survey in California

"Activities and Services of the U S. Geological Survey's Western Region, Menlo Park, California," U S.G S. publication, 1975
Eugene Napier, Geography Program, U S.G.S., Menlo Park, CA
Mary Hill, Public Information, U.S G.S , Menlo Park, CA
Len Gaydos, U S G S Geography Program, NASA Ames Research Center, Moffett Field, CA

U.S. Forest Service Remote Sensing Program

Ray P Allison, U.S Forest Service, Remote Sensing Coordinator, Washington, D C.
"U-2 Optical Bar Photography — Training Notes," U S Forest Service, Region 5, San Francisco, CA

California Environmental Data Center

EDC brochure, July 1978
Summary of EDC activities, prepared for California Environmental Data Users Conference, August 1978.

Geo-Based Information Systems

Robert Hall, Comarc Design Systems, 315 Bay Street, San Francisco, CA
Exerpts from material prepared by Comarc Design Systems on Geo-Based Information Systems for Timber Management, October 1977.
Map rendered by Genia Kungel, Arcata, CA and Mary Paradise, Eureka, CA
"Geo-Based Information Systems in the United States," Tacoma Washington, Planning Department, March 1977
Ross Hall, Comprehensive Planning Organization of the San Diego Region, Security Pacific Plaza, Suite 524, 1200 Third Avenue, San Diego, CA
Paul Wilson, Association of Bay Area Governments, Hotel Claremont, Berkeley, CA
JoAnn R Efforn, Land Use Planner, Pacific Gas and Electric Co , 77 Beale Street, San Francisco, CA

Communication Satellite Users in California

Phoebe Williams, Information Services, WRAP, NASA Ames Research Center,

Moffett Field, CA
Jerry Elliot, Code LB, NASA Johnson Space Center, Houston, TX
Jean Braunstein, Public Service Satellite Consortium, 2480 West 26th Avenue, Denver, CO
Robert Mott, Public Service Satellite Consortium, 4040 Sorrento Valley Blvd., San Diego, CA
"Space Satellites Do World a Service," *The San Diego Union,* April 3, 1977
Mason Riegel, California Department of General Services, Sacramento, CA

October, 1977

HUMBOLDT STATE UNIVERSITY

California Remote Sensing Survey

☐ Agency-Branch ☐ County-Division ☐ Industry ☐ University ☐ Other

* *

Project Director ____________________ Management Director ____________________

Phone # ____________________ Phone # ____________________

Address ____________________ Address ____________________

Area ____________________

Starting Date ____________________ Projected ending date ____________________

Status at Present ____________________

How Funded? ____________________ Overall budget, if not proprietary ____________________

How started? Need that created project? ____________________

Planning units involved? (census tract - forest plots - townships - range - etc.)

Overall size? (# of acres, planning units, etc.) ____________________

What products desired? (Maps - statistics - data base - etc.) ____________________

Data used? (Landsat - Lo Alt - U-2 - Thermal - Other) ____________________

Detail - smallest feature to be determined. ____________________

NOTES

Notice of Change

The following up-dates need to be made in California in Orbit.

Page(s):

Nature of Change:

Reason for Change (optional).

Respondent:

Name ____________________

Title ____________________

Office ____________________

Phone Number ____________________

Address ____________________

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APPENDIX VII

Documentation: Establishment of California Remote Sensing Task Force

Article in Plain Brown Wrapper

Publication of NASA's Western Regional Applications Program

April-May 1979

CIRSS: An Unified Approach to Technology Transfer. Norman's been involved in the CIRSS program with EDC for a year, about as long as Bauer's

been handling the APT "Dale Lumb [Techology Applications Branch chief] decided then that California was too complex to fit under the WRAP umbrella," she recalled "We needed a viable project that would focus on the state, yet stand on its own"

Norman presented her proposal for the integrated pre-ASVT to NASA Headquarters last May With support by Alex Tuyahov and Dick Weinstein there, Sally Bay Cornwell and Dan Richards of Gov Brown's office, Bob Colwell of UC Berkeley, Jack Estes of UC Santa Barbara, and Dale Weirman of CDF, approval for FY'79 funding of $150,000 came through in November

"But," she noted, "the state is contributing more than NASA — $60,000 for the California Department of Forestry project, $125,000 from the state legislature for a county-level user needs survey — and this doesn't include staffing and indirect funding"

To oversee project operations, a CIRSS Task Force has been established with Sally Bay Cornwell, director of the EDC, as chairperson, Mary Arbogast, from the same office, as Task Force Coordinator, and Norman as the NASA representative Other members include Eric Hedlund of Humboldt County, Kenneth Topping of San Bernardino County, Donald Olmstead of Assoc of Bay Area Gov'ts Vashek Cervinka of Dept of Food & Agriculture, Barry Brown of Dept of Conservation, Dr Robert Colwell UC Berkeley, Dr Larry Fox of Humboldt State Univ, Leslie Oliphant of US Forest Service, Eugene Napier and Jim Chamberlin of US Geological Survey, and Floyd Sabins of Chevron Oilfield Research Labs

Sabins, representing the private sector, is head of a five-member Industry Advisory Panel to the Task Force

During the Task Force's first official meeting on March 21, members discussed their immediate goal to make CIRSS relevant to statewide needs and their eventual job of evaluating and advising on any resulting data system

They plan to use the CIRSS project as a testing ground to identify benefits from vertically integrating remote sensing technology into natural resource data collection methods

Vertical data integration, Norman explained, is founded on the concept that a data base appropriate for state-level agencies may also be appropriate for local and federal levels of government "The CIRSS team's primary concern is finding out how far 'appropriate' goes," she emphasized

"We can't build a data base nor can we do demonstrations for every state agency," she insisted "Instead, we'll study conceptual issues by selecting several test areas and concentrating on one discipline forestry We want to show how forestry-related data can be taken from the state to the local level or to the federal level We've also identified the prime agricultural issue as relevant to state and county resource information needs and will sample its integration, too," she added

To test the theory, the CIRSS project will tackle two major areas the first is slanted to concept and design, while the other involves actual small demonstrations Under the conceptual design portion fall a study on vertical data integration and county and state user needs surveys

Key to CIRSS is the data integration study — designed to link all the demonstrations and pull together the inner workings of the project It began to take shape last winter during an exploratory meeting by WRAP's Norman, Frank Westerlund, and Dave Peterson, who is acting as technical advisor, Jack Dangermond of Environmental Systems Research Institute, and Larry Tinney of UC Santa Barbara

This study will explore ways in which data can be integrated into a common base, check the applicability of remote sensing to this base and through a prototype project contracted to ESRI, identify technical issues related to these efforts

Another project, parallel to ESRI's, will study institutional issues involved

The county-level user needs study, funded by the California legislature and manged by EDC, will cut across six of the 15-16 counties who submitted proposals Completed forms for the study started in March should funnel back to EDC's Tim Hays, acting as technical monitor, by October

Mariposa, Mendocino Nevada, Placer, Riverside, and Ventura counties — selected to receive grants ranging from $15,000 to $50 000 — will develop environmental and natural resource information systems, EDC's user needs study will fall under these umbrellas

WRAP's Frank Westerlund is working with Steve Kraus of the Office of Planning and Research to design the state-level user needs study, complementary to the county-level survey, it will address several levels of government with questions on data collection and format and possible commonalities among agencies Initial interviews are to start in early April

CIRSS Demonstration Projects Test New Digital Analysis Techniques. The second major chapter in Norman's integrated pre-ASVT will see Landsat used in four demonstration projects a statewide forest resource inventory, a small-scale prime agricultural lands study, a county forestry project, and a federally-sponsored resource analysis of one USFS district

Under the first project, the California Department of Forestry will use its statewide Landsat-based forest resource inventory (see ***Plain Brown Wrapper*** #4) to respond to a legislative mandate — AB 452, as well as investigate the usefulness of the digital approach

The other state-level project, for the Department of Food and Agriculture, is designed to test the CIRSS analysis methodology in monitoring conversion of prime agricultural lands to urban use in Ventura County Technical support will come from Larry Tinney of UC Santa Barbara

Dr Robert Colwell of UC Berkeley will oversee the county-level demonstration, a forestry application in Mendocino County to demonstrate the uses of digitally mosaicked Landsat and terrain data for mapping fire fuel management zones

On the federal level, the US Forest Service is committing $10 000 for a resource analysis of the McCloud Ranger District WRAP's Don Card will act as technical manager; technical support will come from Larry Fox of Humboldt University and Alice Forbes and Don Campbell of USFS

"The projects have a generic component," Norman concluded "We can take forestry, soils and terrain data, merge these with Landsat data, and then update this information using Landsat. The same procedure could then be used for other data, other disciplines, to arrive at and maintain a common base"

D*R*A*F*T

INTRODUCTION To California ASVT

1954 saw the beginnings of the use of "remote sensing" technology in the State of California. It was not the muted electronic hum of a satellite overhead in those early days, but the buzz of a Cessna. But the spirit of determination to learn about and use the latest practical technology from air and space has stayed alive through some difficult years for those early workers in California. Presently, members of the agencies who were the core group of "remote sensing" have graduated to more sophisticated methods and still form the Core Group. The somewhat tangled history of remote sensing in the Golden State provides the counterpoint against which new melodies are now being cautiously played. In fact, the new melody seems to come from a full symphony orchestra. The implications are more complex and diverse than in any of the 14 western states and as such, deserve special consideration and attention.

In the spirit of the national technology transfer program which NASA initiated in 1977, a decision was made in California to survey the status of use of remote sensing in state and local agencies, federal agencies, universities and industry in the State. This survey has clearly defined what the current projects are, who is involved and what future projects are under consideration. The survey has also identified various problems that have been encountered by those wishing to get involved with the technology itself and at the same time pointed up the fact that critical mass approaches in California. The critical mass is due in part to some relatively uncomplicated factors.

First, enough time has passed from the launching of Landsat I for a wide and common knowledge of the earth resources satellite and its capabilities. Many people feel more comfortable with the idea that satellites, including weather and communications types, are with us to stay. There has been, quite simply, time enough for acceptance of the fact that the man on the moon was not the end of the whole program, and that it was only the beginning. Secondly, as the technology has matured, so has the thinking and reactions of the people of California. It is, quite simply, a technology whose time has come. What, then, are the prime indicators of this critical mass in California?

- a colorful, space oriented Governor.
- key appointments by the Governor, including his space advisor, ex-astronaut Rusty Schweikart.
- creation, within the Governor's Office of Planning and Research, of a State Environmental Data Center. The purpose of the center has been emphasized to be a clearinghouse for environmental data vital to the work of State agencies. Further, it is to be a focal point for State remote sensing activities. The Director of this Center is Ms. Sally Bay Cornwell, formerly Remote Sensing Task Force Director of the National Council of State Legislatures.
- activation of the California Remote Sensing Council, fully acknowledged by the Administration as an advisory group on Remote Sensing Affairs in California and composed primarily of the core group who first initiated remote sensing activities in the State.
- wide, if scattered and isolated, use of remote sensing technology within various agencies, universities, counties and entities in the State.
- a wide range of remote sensing at universities, State Colleges and community colleges. This includes education in basic theory and applications.

- recent legislation that requires statewide resource inventory, assessment, monitoring and updating and that have requirements best fulfilled by use of remotely sensed data in the workplan. Further, certain legislation has specifically indicated use of remote sensing technology for implementation of work plans.

Inherent within the "critical mass" of California are several real problems which must be addressed. The user driven attitudes developing within the State are bringing on a wave of interest that may well turn into a tsunami. Properly addressed, the problems can well turn the State of California into the most exciting and dynamic example of technology transfer yet seen in the United States. The problems seem to fall quite naturally into major categories.

1) A Coordination Category. Indications are very strong that a unified and coordinated approach must be powerfully supported by NASA Ames Research Center. The indicators here are manyfold·
   - State and Federal agencies are becoming involved in many isolated and relatively small projects.
   - Counties are becoming seriously involved in the use of remote sensing, but generally relating only to County problems.
   - Universities through NASA contracts and grants are involved in scattered projects with agencies and counties.

   All these indicate that NASA may be expending dollars for similar types of activities that should be integrated and coordinated for better utilization of funds.

2) Personnel Resources and Training Category. The survey and other indications show quite clearly that wider and more practical use of remote sensing would occur if key personnel in State, Federal, and local agencies were trained in the techniques of remote sensing. This problem is one that reflects directly on NASA-ARC's capabi-

lity to respond to the new wave of interest in receiving and using such training. The question that must be answered is whether NASA-ARC will be able to properly support the stated desires of such agencies to receive training and implement remote sensing projects in their agencies. This problem must be dealt with in both a budgetary and in-house personnel sense by NASA-ARC.

3) A User Needs Category. Strong indications are evident from all sources of information that a statewide user needs survey is urgently needed. This may be the place to begin.

4) Basic Information Category. This problem is one that has been revealed quite recently. Due to the wave of interest, and critical mass of the State of California, it now appears that transfer of technology would be greatly facilitated by an underlying, general data base from which all projects could draw. This concept would provide a single date classification of the 30 some Landsat scenes that cover the state. The date of coverage, classification scheme, computer processing and analysis would have to be agreed upon by those known and potential users and tapes made available for further classification according to individual agency needs.

Accomplishment of this task would fill the needs of both the State and NASA-ARC in a host of ways. Primary among those is a more uniform and integrated approach to remote sensing projects, a uniform product that would be readily accessible and more adaptable to the computerized geo-based information systems now being started up all over the state. Several counties, cities and agencies already have, or are working on these computerized data bases and it is the intent of all to incorporate classified Landsat data into these information storage and retrieval systems.

In conclusion, the indicators are clear. California, as a state appears to be ready to accept the technology offered by NASA. The problems are ones of coordination, personnel, training, identifying user needs and providing basic information from which to draw. Within the existing selection of response mechanisms to the stated conditions, and currently in use by NASA, the ideal appears to be a California ASVT.

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HUMBOLDT STATE UNIVERSITY
Graves Bldg, (No 25) Graves Annex Bldg (No 30)
ARCATA, CALIFORNIA 95521 -- TEL (707) 826-3731 (2,3)
REMOTE SENSING AND TECHNOLOGY TRANSFER PROJECT

TOM PARSONS
Director

American Indian Languages and Literature Program

Assistance to Northwest Indian Cemetery Protective Ass'n

Community Education Project

Humboldt Co Recreation Project

Indian Mainstream Industries Project

Indian Manpower Development Project (C E T A Title III Prime Sponsorship)

Kotim Een Karuk Ceremonial Society

Retired Senior Volunteer Program (Action - RSVP)

Senior Nutrition Project

Student AMA American Indian Health Project

Wood for Seniors Project

M E M O R A N D U M

DATE: March 9, 1978
DBH-78-CGeneral

TO: Dr. Dale Lumb

FROM: Donna B. Hankins DBH
Project Director

RE: California Planning and Technology Transfer Model in California

- - - - - - - - - - - - - - - -

After numerous conferences, meetings and discussions with representatives of Unviersities, State Colleges, Community Colleges, agencies (State-local-Federal, NASA-Arc and industry throughout California for over a year, I would like to share some thoughts with you as to how some order could be brought into the existing chaotic state of affairs in California. As you know, to construct an effective model for transfer of technology within any region, careful attention must be given to "where things are at" prior to actual initiation of any plans. I believe we have now felt our way nearly around the elephant, and are ready to begin figuring out trunk from tail. The enclosed material is a rough outline and statement of those things I believe must be considered within the next few weeks and months, and represent the key problems that, once addressed and resolved, will lead to an orderly approach to remote sensing and technology transfer in California.

This document also represents the basic portion of discussions held at NASA-ARC on Monday, March 6, 1978, between myself and Sue Norman, and should serve as a preliminary report to the California Survey.

cc: Ben Padrick
Robin Welch
Chuck Poulton
Phoebe Williams
Camie Butler
Sue Norman
Larry Fox
Joe Webster
Kamila Plesmid
Mike McCormick

Sent copy to Sally Bay Cornwell on request

MAJOR ELEMENTS OF CALIFORNIA TECHNOLOGY TRANSFER
QUESTIONS, PROBLEMS AND RECOMMENDATIONS CONNECTED WITH THEM

I. Institutions of Higher Learning

A. University of California (Berkeley - UCSB - UCSD - UC Davis - U Cal Riverside - Other)

1. Most remote sensing in California happening through University Research Centers!

2. Known "Centers of Excellence" in Remote Sensing are at the leading edge of technology and should continue to be supported for these activities in opinion of all.

3. "Chartered" to do research -- have research labs -- can successfully interact with any entity "outside", in community, on contract.

4. Does this conflict with the WRAP philosophy? Is technology really transferred? Is research often applied as well as basic leading to Universities actually providing contractual services for agencies, and entities? Is this a bad thing? How do we resolve the fine line between these activities?

5. NASA Headquarters and Center dollars often support conflicting and duplicated university efforts yet NASA and other agencies do not have easy access to or dissemination of the results of these efforts. How is this to be resolved?

6. Need a single focal point in State -- one person.

B. California State Universities and Colleges (Humboldt State and others).

1. Have very little real way to deal freely in the "outside" world. Research facilities limited and sparse. Individual efforts to integrate and teach remote sensing in various curriculum areas severely hampered, but well underway despite problems. How do these [illegible] get off the ground? Can we train professors at Ames? Or get [illegible] university groups to train them? They could then go back to schools

and integrate into existing curriculum areas, providing long-term solutions to problems.

2. Most of these schools have no real way to interact with the community. Their charter says -- must be "academically relevant." One mechanism is the Center for Community Development at Humboldt State University--the only one of its kind in California. Present operating charter could be expanded by legislation to include Technological Applications and Industrial Development Directorate -- if successful in a pilot program, each State University could have a Center for Community Development increasing potential for wider use of NASA (and other) technology to solve community problems and enhance industrial development.

3. Need a single state focal point -- one person.

Note: Both Universities and State Colleges are on elderly, limited computer systems. Very few computers used for other than processing enrollment, finances, payroll, etc. Except in UC. dedicated computers obtained on grants

C. Community Colleges

1. Interest and charter to serve and interact directly with public, industry and agencies.

2. Usually have an astonishingly large budget to provide innovative answers to community problems. Also have NEW computer systems.

3. Can develop "packages" or programs to order -- for outside entities, i.e. curriculum development, teaching aids, workshop materials, etc., as well as actually provide the environment for a wide variety of specialized voc/tech courses. May well fill a very definite and documented need. They will need some support and lots of direction from NASA.

4. California Remote Sensing Advisory Council (CRSAC) noted at its charter meeting that they would recommend a state civil service position be instituted (via legislation) called Remote Sensing Technician. The Community College can provide voc/technical courses (short or medium long) for a wide variety of individuals needing this "quick-training". See Dr. John Russell, West Valley College, Interim Campus, Santa Clara (246-8201). (I believe this should be vigorously pursued).

Note: See Nick Muhlenburg's Survey of Colleges and Universities, California section. Basically same as

II. California State Agencies (will be carefully documented by the forthcoming California Survey).

A. Backdoor approach -- whole state activities.

1. Several agencies involved in Statewide surveys that can use or wish to use remote sensing techniques.

   .CDF - AB 452 - Statewide Forest Resource Inventory - 525K price tag

   .Cal Fish and Game - Statewide Wildlife Habitat Inventory - 200 K

   .State Water Resources Control Board - "Clean Water" Study - 500K price tag (from EPA)

   .USFS - Statewide Forest Maps - unknown price tag 60-80K

2. Will these statewide studies be interactive?

3. Will they be properly supported by NASA?

4. Numerous Federal agencies heavily engaged in remote sensing activities, need to integrate activities with State Agencies.

5. Should the agencies opt for remote sensing techniques?

6. Need two or so focal persons in State.

B. Bits and Pieces Syndrome (also documented by Calif. Survey)

1. Many agencies getting involved in small ways, small projects, limited use of remote sensing techniques due to budgetary restraints and lack of trained personnel.
2. Those same agencies have resource management problems that would benefit from a regional or statewide approach versus bits and pieces. Old-line agency people have a "resolution" problem -- airplane versus satellite.
3. Need a top-level (Governor's Office or Secretary of Resources) mandate to be able to develop a competent program for sensible use of remotely sensed data in appropriate places -- a stated need.
4. Numerous Federal agencies heavily engaged in remote sensing activities. Need to integrate activities with State agencies.

C. County Involvement

1. This area continues to be of great potential for use of remote sensing in solving local problems.
2. Most County problems appear to require greater resolution capabilities than currently exist in Landsat. A common thought is that if the whole state were flown on a regular basis (every 3-5 years, for example) counties would use extensively (U-2 flights).
3. Most counties need to unify efforts with other counties having similar regional characteristics, i.e. No. Western California Coastal Counties -- 6 North Eastern Mountain -- Central Valley Counties, etc., due to budgetary restraints, lack of trained personnel and limited computer capabilities. Regional county associations would have extensive use of Landsat data at existing resolution.

U2 flights

4. County concerns may be well approached through the mechanism of the California County Supervisor's Association (CCSA), who meet on a regular, regional basis and a few times a year on a statewide basis.
5. There are already several California counties and communities involved in intensive and highly sophisticated remote sensing projects, i.e. Ventura, Orange, Sonoma, Humboldt (just getting started), ABAG (S.F. area), etc., that include construction of computerized data bases, etc., in some cases.
6. The Counties need to establish a focal person within State -- drawn from CCSA.

Note 1: Both A, B, and C sections would benefit from a Statewide user-needs survey coupled with assessment-of-existing data survey. Recommend using the PNW User Needs Matrix for guidelines.

Note 2: A single focal point has been identified for remote sensing activities in California -- Sally Bay Cornwell and the Environmental Data Center.

Question: Can this focal point be truly coordinated with the needs of California? Can "we" (universities, industries, agencies, NASA, etc.) really support the functions of the Environmental Data Center and is there a desire in the Governor's Office, Office of Resources, etc., for those of us "out" in the State to do so? Must clarify this point soon.

III. Industrial Interaction.

A. Is industry being given a fair shake in the technology transfer scene from NASA?

B. Is industry properly represented in planning for 14 western (or 50-allover) states?

C. What can "they" collectively or singly offer to the technology transfer model in California? Have "they" been approached yet to participate? Who is "they"?

D. Can industry really provide a better "deal" for some (or all) users, than NASA?

Note 1. Many agencies dealing in remote sensing really do not want to get involved with training a la WRAP -- would rather deal with industrial or contractual services of some kind.

Note 2: I recommend that a strong, well versed individual, known for good organizational and leadership capabilities from within aerospace industry be obtained on an IPA to head up industrial liaison in 14 western states. I also recommend that this individual's initial task be to work within California. A list of names of those persons interested can be provided.

IV. NASA - Technology Transfer in California.

A. Is NASA-ARC prepared to deal with the complexities of the California Technology Transfer scene. Is our in-house act together?

1. Are the proper people <u>on board</u> to do the jobs needed? (civil servants and grant people)

2. Are some people not yet CLEAR as to what the WRAP program is all about? And their specific roles? Are guidelines available for those who aren't clear?

Note: I need to see the PLAN Westerlund is finalizing.

3. Is everyone (every single last person) briefed on a regular basis as dynamics of the situation change?

4. Are "civil servants" and grant people well integrated and working side-by-side? If not, why not?

5. Have the real, hard-core problems of training people (who are to get involved in WRAP demo projects) been addressed?

ANALYSIS NEEDED SOON!! DEFINES SKILLS TO BE TAUGHT

a. Analysis made of need items -- who is doing this?

b. Job task analysis -- who is doing this?

c. Training task analysis -- specific people defining?

6. How soon can implementation of #5 be instituted?

IMPLEMENTATION MUST BE SOON!!

DEVELOP VARIOUS PRODUCTS AND METHODS NEEDED TO TRAIN

a. Develop competent training materials -- who will do?

b. Develop tests for them -- who will do this?

c. Selection of media and methods -- who will do this?

d. Conduct (inhouse) test instruction -- who will do this?

e. Conduct sample demo (outside) tests -- who will do this?

EVALUATION MUST BE PLANNED FOR! CONTINUOUS ASSESSMENT OF EFFECTIVENESS

7. Are any evaluations (internal/external) planned for 5 and 6 above/

8. Have allover WRAP policies and guidelines been clearly defined (at least for this next year?) Will the PLAN cover this so that anyone can find guidelines in it, for their particular area of endeavor?

B. Is NASA Ames cognizant of the full complexities of the transfer program in California and ready to deal with it? Is there a strategy developed?

C. Is NASA Headquarters ready and able to respond to a well thought out plan for California? (i.e. ASVT plans, short and long-term budget needs, etc.)

V. The Political Scene - an overlay to other complexities.

A. The Governor's Office and his chosen people.

1. Young, brilliant men and women mostly new to the political field, rapidly maturing there, highly competent and extremely well-versed. Responsive to state needs. Looking to those "out" in the State for

help in the remote sensing scene? Perhaps. Mostly viewing it as a complex one, but working on their focal point and developing it to accommodate a host of environmental data problems. Believe they would be receptive to a well-thought out plan -- a Straw Man approach to support the Environmental Data Center and Sally Bay Cornwell.

B. The Governor's and R. Schweikart's apparent initial interest in satellites is primarily communications satellites, NOT Landsat. Needs clarification. Communication satellites are operational -- Landsat is not -- political problem.

C. There is a strong use of NOAA/Weather Satellite Data in fisheries and other resource groups in California -- is this area being overlooked as being corollary to Landsat data? This question has been asked by State people.

D. How does the California Remote Sensing Advisory Council (CRSAC) -- Sewing Bee group -- fit in the picture? Composed of many people who have been involved in earlier California attempts to "get into" remote sensing, they have long memories and recall Earl Davis days with great clarity. Appears that they wish to guide, advise, recommend, promote--can be a vital source of information and assistance--but they also state that a mandate from top levels is needed for use of remote sensing technology in state agencies to become a reality.

SUMMARY AND RECOMMENDATIONS

The above items point up a strong need for a California Remote Sensing Task Force to resolve some of the most pressing needs and prepare a working plan for the Governor's Office. Should members be appointed by Governor? Needs to be, for effective work. <u>Composition and Makeup</u>: A small working group, can vary, but initially should include representatives of:

*1. University of California - 1 person, the focal person.

*2. State Colleges - a focal person

*3. Community Colleges - a focal person

4. California Agencies - a focal person or two -- perhaps drawn from CRSAC?

5. Secretary of Resources or an alternate.

6. Sally Bay Cornwell - head up? + Communications Division representative.

*7. Industrial liaison - WRAP?

8. NASA-ARC WRAP person, non-industrial.

*9. California Environmentalist - ??

*10. NOAA-NESS Representative.

*11. One or two Federal (major remote sensing users) agencies using remote sensing in resource management in California.

12. Mike McCormick!! For sure!

13. One NASA headquarters person??

14. One person from California Regional Commission or Economic Development Department.

*15. One person drawn from California Board of Supervisor's Association.

<u>Tasks and Responsibilities</u> can include, typically:

1. Establish working relationships.

2. Ramrod user needs survey/existing user data survey - prepare "straw man" plan for Governor's office.

---

*Persons identified who would consider serving on such a Task Force.

3. Back up and recommend to State Environmental Data Center.

4. Work with and respond to enquiries from legislators.

5. Provide a flow through and exchange of information.

Goals. Prepare a real working plan for use of remote sensing in California.

Phases of activities. Start-up Note: Needs presentation to Governor's Office prior to anything else.

Start-Up

1. Meet for one or two get acquainted planning sessions -- two (2) day sessions, one month apart.

2. Prepare plans and recommendations -- 1-3 months separately.

3. Meet for another 2-day session -- finalize working plan to submit to Governor's Office. Plans would include recommendations for demonstration projects as well as use of remote sensing in agencies.

By End of 6 months

4. Present plan to Governor-1 day? Budget guidelines also.

5. Follow-up, as needed, based on response from 4.

End 1st Year & Every 4-6 Mo. Thereafter until End 2nd Year

6. Meet as needed, or once or twice a year to review status as dynamics of state remote sensing activities demand.

7. Disband, if no longer needed OR

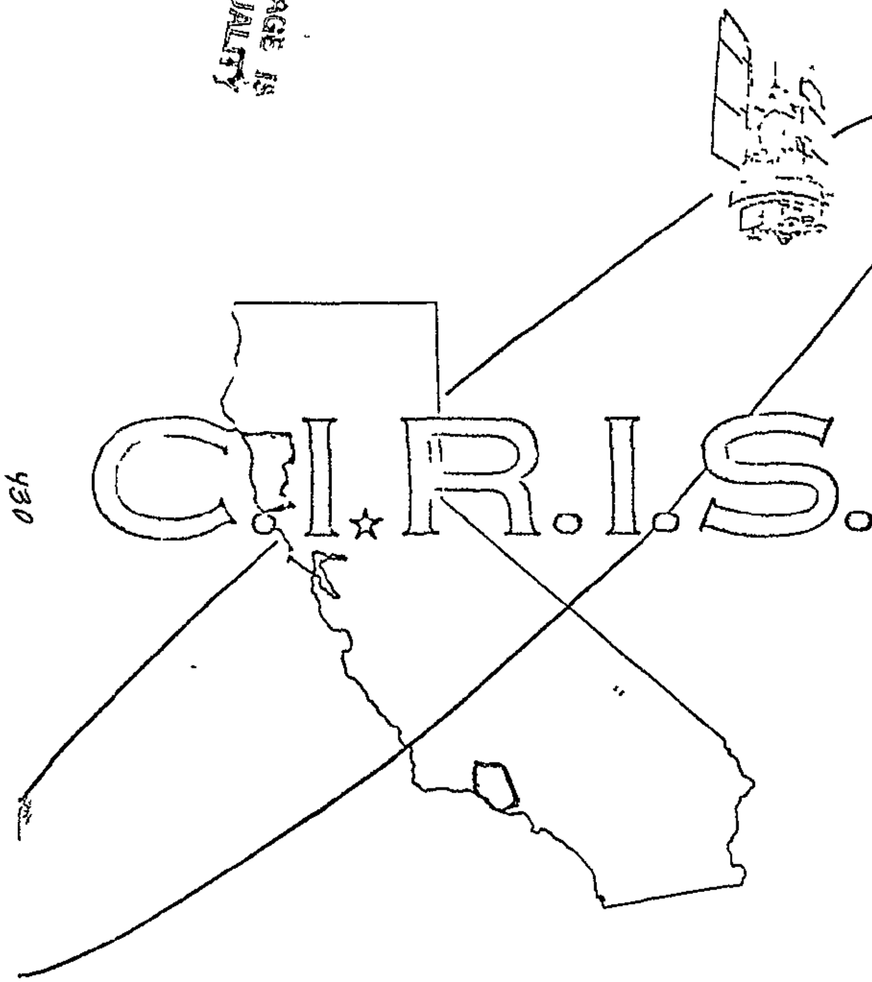
8. Continue with 2-year staggered terms.

9. Keep in touch via letter and phone.

ORIGINAL PAGE IS OF POOR QUALITY

I recommend that the value of what is done by the Task Force and what it can accomplish for the future be strongly emphasized. I would think that travel and per diem support for these individuals could well be looked upon as an investment by the groups they represent.

Later as need for funding is demonstrated some assistance could be sought from a variety of sources.



COOPERATIVE NASA FEDERAL STATE LOCAL
PRIVATE INDUSTRY UNIVERSITY
ASVT

CALIFORNIA INTEGRATED RESOURCES INFORMATION SYSTEM

NASA PROPOSED STUDY OF REMOTE SENSING APPLICATION IN CALIFORNIA

OBJECTIVE: TO PROVIDE AN INTEGRATED APPROACH TO CURRENT REMOTE SENSING PROJECTS IN CALIFORNIA WHICH ARE FUNDED BY NASA.

TECHNICAL PLAN:

- O MAJOR TECHNICAL AREAS WILL SUPPORT FORESTRY, AGRICULTURE, RESERVOIR STUDIES, LAND USE, AND WATERSHED MANAGEMENT.
- O PROJECTS REPRESNETATIVE OF ALL USER/TECHNICAL DISIPLINE COMBINATIONS WILL BE INCLUDED.
- O PROPOSED USERS WILL INCLUDE COUNTY, STATE, AND FEDERAL AGENCIES AS WELL AS REGIONAL GOVERNMENT ASSOCIATIONS
- O DATA BASE INTEGRATION WILL BE A KEY OBJECTIVE OF THE STUDY

MANAGEMENT:

- O A TASK FORCE WORKING GROUP, CHAIRED BY THE STATE ENVIRONMENTAL DATA CENTER REPRESENTATIVE AND COMPOSED OF MEMBERS OF ALL AFFECTED USER GROUPS WILL BE FORMED.

TASK FORCE WORKING GROUP

FRAMEWORK:

STATE-ENVIRONMENTAL DATA CENTER (1)

STATE LEGISLATURE - ASSEMBLY (2)

STATE LEGISLATURE - SENATE (2)

STATE BOARD OF COUNTY SUPERVISORS (1)

FEDERAL USER AGENCY (1)

REGIONAL GOVERNMENT ASSOCIATTIONS

- ABAG (1) Lumis – ?
- SCAG (1)

COUNTY (1)

STATE

- OFFICE OF SECRETARY OF AGRICULTURE AND SERVICES
  - DEPARTMENT OF FOOD AND AGRICULTURE (1)
- OFFICE OF SECRETARY OF RESOURCES
  - DEPARTMENT OF FORESTRY (1)
  - OTHER (1)

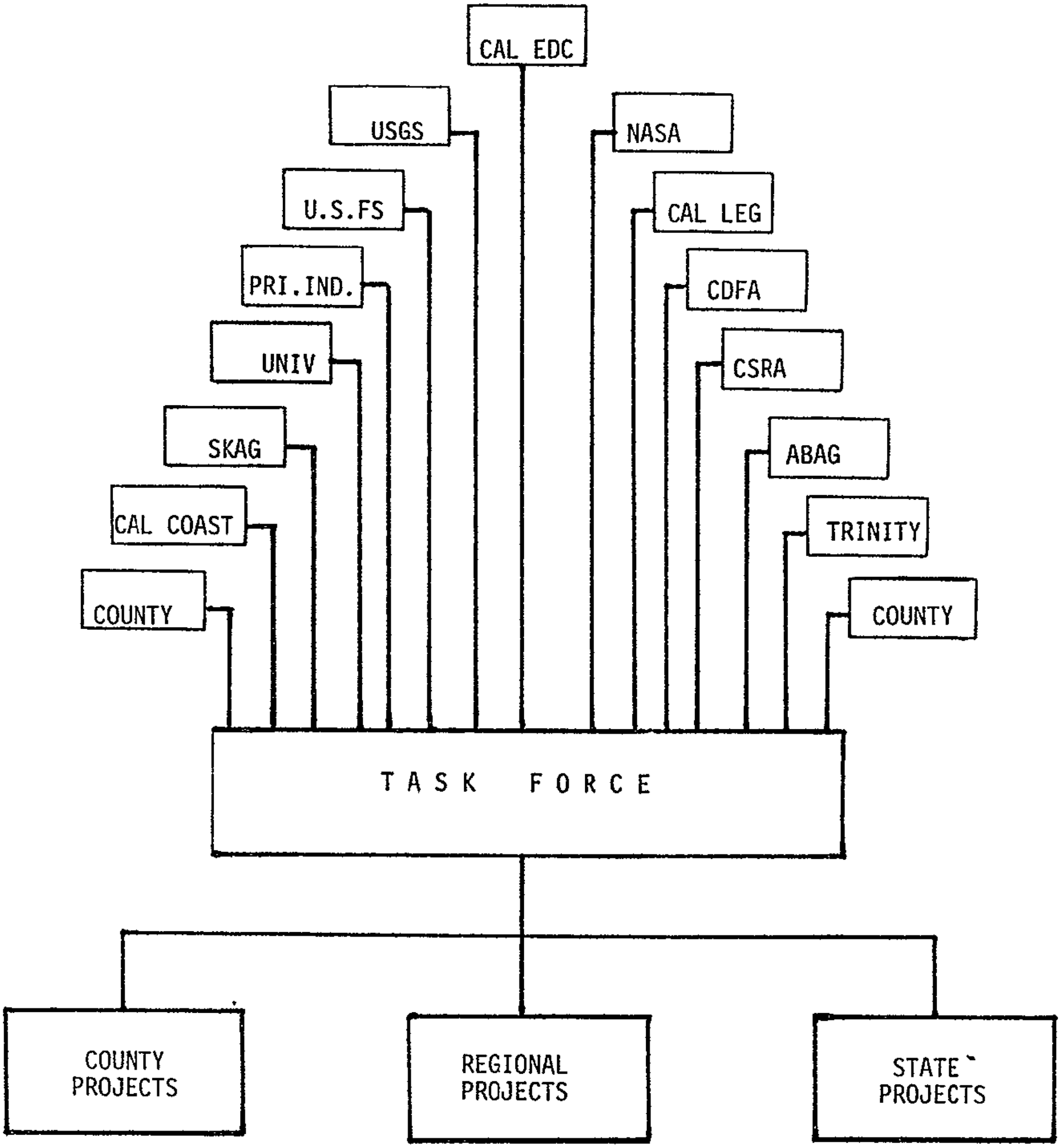
NASA-ARC (1)

UNIVERSITY (1)

STATE COLLEGE (1)

CHAIRMANSHIP

ENVIRONMENTAL DATA CENTER



POSSIBLE FRAMEWORK

for TASK FORCE WORKING GROUP

DATA BASE INTEGRATION

THE STATE OF CALIFORNIA IS IN THE PROCESS OF DETERMINING AND COORDINATING ENVIRONMENTAL DATA NEEDS THROUGH THE EDC. A PORTION OF THESE DATA NEEDS WILL RELATE TO REMOTE SENSING. THESE NEEDS WILL BE USED AS A BASIS FOR REMOTE SENSING DATA WITHIN THE STATE AND WILL HELP FOCUS AND DIRECT NASA FUNDED REMOTE SENSING ACTIVITIES IN CALIFORNIA.

THE TASK FORCE CONCEPT WILL SUPPORT THE EDC ACTIVITIES IN REMOTE SENSING BY:

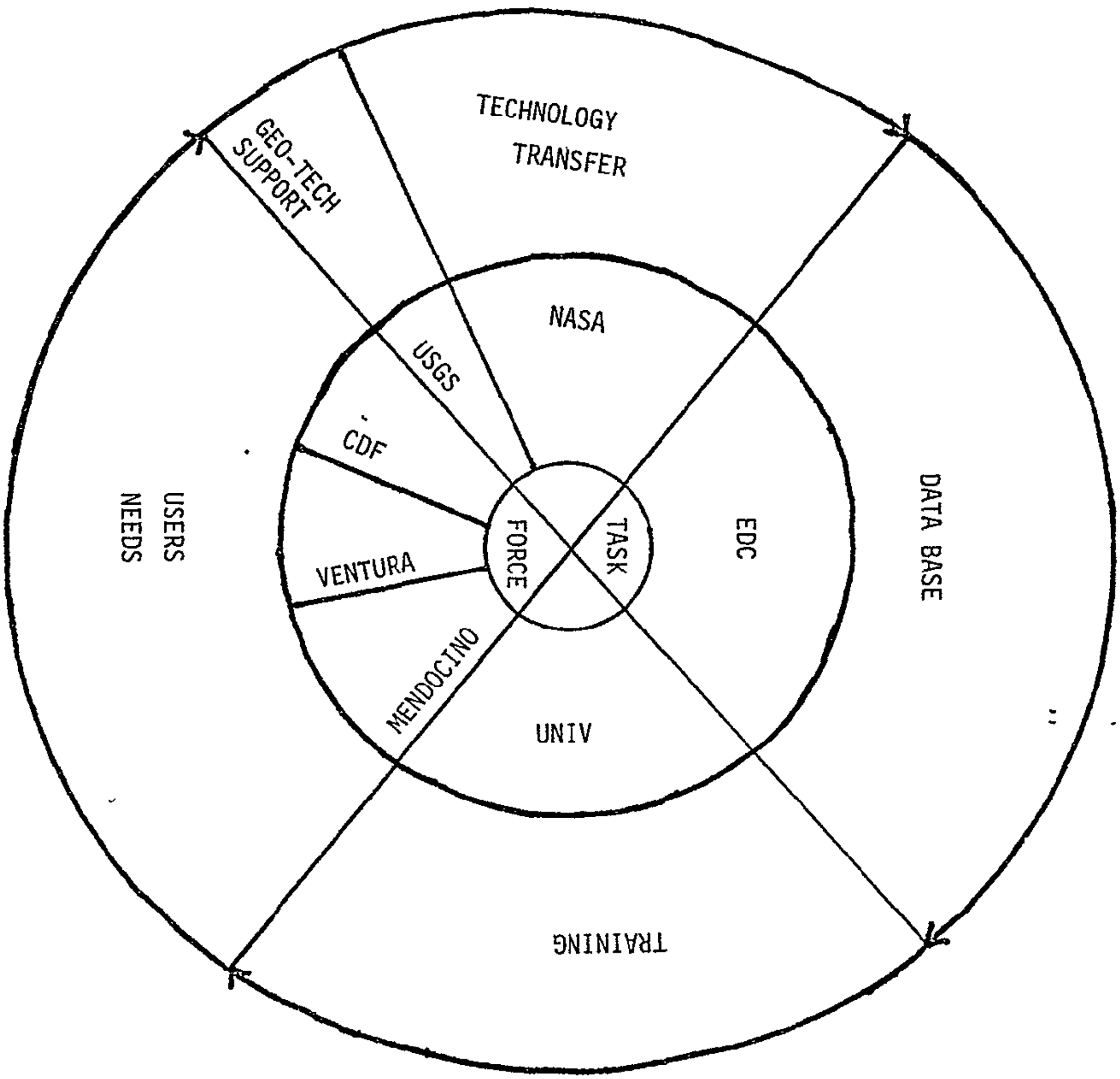
PROVIDING A COMMUNICATION NETWORK AND A FOCUS FOR THAT PART OF THE EDC ACTIVI RELATED TO REMOTE SENSING.

434. SINCE LEGISLATIVE SUPPORT IS REQUIRED FOR FUNDING, INCLUDING LEGISLATIVE REPRESENTATIVES AT THE INITIATION OF THE REMOTE SENSING PROJECT TASK FORCE WILL ALLOW TRANSITION TO A SMOOTH OPERATIONAL STATUS.

THE PROPOSED NASA CALIFORNIA ASVT WILL SUPPORT THE EDC'S ROLE AS A FOCUS FOR INVIRONMENTAL NEEDS BY:

COORDINATING THE EXISTING FRAGMENTED ACTIVITIES CURRENTLY ON-GOING IN REMOTE SENSING AND BY PROVIDING A FOUNDATION TO FOCUS AND COORDINATE NEW PROJECTS WITHIN REMOTE SENSING

AS THE EDC PROCEEDS WITH CONCEPT FORMULATION AND USER NEEDS ASSESSMENT, THE TASK FORCE FOR THE NASA PROPOSED ASVT WILL SIMULTANEOUSLY 1) FOCUS THE ON-GOING PROJECTS 2) ASSURE THAT THESE ON-GOING PROJECTS WILL BE RESPONSIVE TO THE CONCEPTS FORMULATED BY THE EDC 3) ASSURE THAT ANY ADDITIONAL PROJECTS FUNDED WITH THE ASVT WILL BE CONSISTENT WITH, AND RESPONSIVE TO, THE GOALS FOR THE STATE EDC SINCE A MAJOR OBJECTIVE OF NASA PARTICIPATION IS TO SUPPORT USER NEEDS.


TECHNOLOGY TRANSFER
GEO-TECH SUPPORT
USERS NEEDS
DATA BASE
TRAINING
NASA
USGS
CDF
VENTURA
MENDOCINO
UNIV
EDC
TASK FORCE

urban encroachment of prime agricultural lands, and forest reserves. Even though the Landsat program was still considered experimental, a number of states began using it to address their problems. As budgets become even tighter and states need even more cost-effective approaches to data gathering, Landsat is rapidly becoming a necessity to satisfy federal demands for more information from states. Yet, Carter blandly assumes there is no apparent need for this technology. Apparently the concerns expressed by Governor Brown, as well as Governor Lamm (Colorado), Governor Busby (Georgia), and others have fallen on deaf ears.

Congressional Action

Senators Adlai E. Stevenson, III (Illinois) and Harrison H.

[illegible] 3555. It establishes a framework for a worldwide information system, an orbital civilization, exploration of the solar system, and the development of other space activities to preserve and expand U.S. leadership in space. Schmitt's first space policy implementation bill, S.3541, calls for developing solar power satellites.

While the Space Policy bills are similar and likely to be combined, the state/local need for a remote sensing information system clearly rests on the fate of S.3589. To help secure its passage, the remote sensing users in California should contact their legislators and encourage those in other states to do likewise. For further information, contact Sally Bay Cornwell, Environmental Data Center, (916) 322-3784 or Jim Gehrig, U.S. Senate Committee on Commerce, Science, and Transportation, Washington, D.C. 20510.

STATE NEWS

CIRIS Task Force Forming

The National Aeronautics and Space Administration (NASA) has established the California Integrated Remote Sensing System (CIRIS) for fiscal year 1978-79 to be managed by a task force chaired by the director of the Environmental Data Center.

The CIRIS Task Force will work toward integrating county, regional, and state remote sensing projects and data needs. It will provide technical and administrative support required for efficient project management and establish guidelines for future projects.

CIRIS has broad support in California and will seek assistance from many agencies. The California Legislature will provide legislative support. The Environmental Data Center will represent state users and provide technical assistance on data structures, integration, and compatibility. California state, local, and regional governments will represent users. They will set priorities and test the feasibility of different operations. The University of California and the California State Colleges and University System will provide technical advice on remote sensing technology and will provide training and support in information systems and data structure. The National Aeronautics and Space Administration-Ames Research Center will administer the project and provide general technical support. The U.S. Geological Survey will take the lead in digitizing and structuring information systems and land use data. Finally, the U.S. Forest Service will offer assistance in acquiring data and establishing data structures.

Private industry will provide technical support on analyzing remote sensing systems, evaluating different approaches, and in developing data base concepts. Private companies plan to establish an advisory group to coordinate their efforts, with the Chairman as member of the CIRIS Task Force. Additional group representatives may be added to the Task Force, if needed.

For further information contact:

Sally Bay Cornwell
Environmental Data Center
(916) 322-3784

Interim Data Catalog Soon Available

The Environmental Data Center's interim catalog of state agencies will be available on January 2, 1979. It lists kinds of data by state agency, indicating whether the agency is a user or collector. The final state data catalog will be published in June 1979.

The entire cataloging is now approximately 75% complete; six agencies have been cataloged. EDC staff are currently working with the Departments of Food and Agriculture and Water Resources to enter their data holdings.

If your agency would like to receive a copy of the interim data catalog or to have its data entered, please contact:

Timothy R. Hays
Environmental Data Center
(916) 322-3784

PROPOSED FIRST YEAR (FY 79) CIRSS ASVT FUNDING

SUMMARY

OCTOBER 23, 1978

- PROPOSED FUNDING - FY 79 TOTAL $145K

- MAJOR EMPHASIS
  - VERTICAL DATA INTEGRATION METHODOLOGY
    (STATE, REGIONAL, COUNTY GOVERNMENTS)

  - PRACTICAL DEMONSTRATION IN THE FORESTRY DISCIPLINE AREA AT SEVERAL LEVELS
    OF GOVERNMENT

- CURRENTLY THERE IS SUBSTANTIAL USER COMMITMENT

FIRST YEAR APPROACH

- FIRST YEAR IS LARGELY A PLANNING AND STUDY YEAR WITH DEMONSTRATIONS IN FORESTRY

- THESE PLANNING EFFORTS CAN LARGELY PROCEED IN PARALLEL

- EDC WILL COORDINATE AND CHAIR THE CALIFORNIA TASK FORCE

- EDC WILL INITIATE AND GUIDE FORMATION OF THE INDUSTRY ADVISORY GROUP

- DOCUMENTATION, APPROPRIATE FOR USE BY OTHER STATES WILL BE PREPARED

CONCEPTUAL APPROACH

INFORMATION INTEGRATION METHODOLOGY EXAMPLE

AS THE INTEGRATED DATA BASE CONCEPT IS DEVELOPED, IT MAY BE POSSIBLE TO ACHIEVE TECHNOLOGY TRANSFER TO SEVERAL LEVELS OF GOVERNMENT AT THE SAME TIME

439

COUNTY NEEDS

- DATA FOR ENVIRONMENTAL IMPACT STATEMENTS
- LAND USE/COVER
- SOILS
- GEOLOGY
- ETC.

STATE NEEDS

- RESOURCE SPECIFIC INFORMATION
- DATA SUMMARIES BY COUNTY, WATERSHED
- LAND USE/COVER
- TERRAIN DATA

ETC.

APPENDIX IX

Documentation: Examples of Training Courses Given by WRAP staff (Moffett Field staff)

* Summary Report - "Hawaiian State and County Agency Personnel Training Course" August 1978

* Summary Report - "Training for Montana Demonstration Projects" August 1978

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Graves Bldg, (No 25) Graves Annex Bldg (No 30)
ARCATA, CALIFORNIA 95521 — TEL (707) 826-3731 (2,3)

TOM PARSONS
Director

American Indian Communities TV Project

American Indian Languages and Literature Program

Community Education Project

Humboldt Co Recreation Project

Indian Mainstream Industries Project

Kotim Een Karuk Ceremonial Society

Multi-Cultural Education Project

N A S A Remote Sensing Technology Transfer Project

National American Indian Repertory Theatre Project

Northern California Health Systems Agency Support Project

Redwoods Community Development Council Project

Wood for Seniors Project

SUMMARY REPORT

HAWAIIAN STATE AND COUNTY AGENCY PERSONNEL TRAINING COURSE

SPONSORED BY

NASA AMES RESEARCH CENTER

SUBMITTED BY:

ROBIN I. WELCH

DIRECTOR,
USER ASSISTANCE
WESTERN REGIONAL APPLICATIONS PROGRAM

AUGUST 1978

IN COOPERATION WITH CALIFORNIA'S NORTHWEST COUNTIES

441

TRAINING REPORT

HAWAIIAN STATE AND COUNTY AGENCY PERSONNEL TRAINING COURSE

Dates & Location:

First week - University of California, Berkeley
November 7-11, 1977

Second week - NASA Ames Research Center
November 14-18, 1977

Persons Attending:

Patrick Costales - Department of Land & Natural Resources
Norman Hayashi - County of Hawaii
Abe E. Mitsuda - Department of Planning & Economic Development
Michael T. Munekiyo - Department of Planning & Economic Development
Robert H. Nagao - Department of Agriculture
Edwin Petteys - Department of Land & Natural Resources
Richard Scudder - Office of Environmental Quality Control

First week instruction - Held at University of California, Berkeley, under contract to the University (see attached Class Schedule). Instructors included Humboldt State University Foundation personnel and University of California, Berkeley personnel.

Second week instruction - Held at NASA Ames Research Center (see attached Class Schedule).

Materials Provided:

Syllabus prepared by University of California, Berkeley. Data products at Ames Research Center.

Training Plan:

Training dealt primarily with satellite and aircraft data. The first week presented the basics of remote sensing data collection and processing technology that will be used in the Hawaii demonstration projects. The second week provided hands-on training on the use of computer digital data

Training Plan (Continued)

processing of Landsat data supported by U-2 data of part of the Island of Oahu. The group was introduced to several types of digital processing hardware and methods that may be used in the demonstration projects being planned for Hawaii.

The WRAP staff provided further technical assistance in planning for demonstration projects during several visits to Hawaii.

Monday, November 7, 1977 124 Mulford Hall

8:00	Introduction, Course Schedual, Issue of Syllabus and Equipment.	Welch and Da
8:45	History of Remote Sensing.	Daus
10:00	Coffee Break.	
10:15	Multimedia Presentation at Lawrence Hall of Science.	Daus
11:30	Field Stop at Lawrence Hall of Science overlook.	Daus
12:00	Lunch.	
1:00	Principles of Remote Sensing (Part I).	Daus
3:00	Coffee Break.	
3:15	Problem Set-Photo Mission Planning, Photo Scale.	Welch
5:00	Adjourn.	

Tuesday, November 8, 1977 124 Mulford Hall

8:00	Principles of Remote Sensing (Part II).	Daus
10:00	Coffee Break.	
10:15	Sources of Remote Sensing Data and Assistance.	Daus
10:45	Image Interpretation Techniques and Procedures (Part I).	Katibah
12:00	Lunch.	
1:00	Photo Measurement Procedures.	Daus
2:15	Inventory Design and Sampling.	Thomas
3:00	Coffee Break.	
3:15	Remote Sensing in Resource Information/Management Systems.	Thomas
4:30	Quiz.	Daus
5:00	Adjourn.	

Wednesday, November 9, 1977 124 Mulford Hall

8:00	Photo Interpretation Techniques and Procedures (Part II).	Colwell
9:15	Application of Remote Sensing to Agriculture, Change Detection, Forestry, Hydrology, Land Use and Range.	Colwell
10:00	Coffee Break.	
10:15	Application of Remote Sensing to Coastal Zone Resources, Non-Point Source Pollution and Erosion.	Estes
12:00	Lunch.	
1:00	Interpretation Workshop (San Pablo Reservior Test Site).	Colwell
2:00	Field Trip to San Pablo Reservior Test Site.	Colwell
5:00	Adjourn.	
	Reading Assignment	

Thursday, November 10, 1977 124 Mulford Hall

8:00-5:00	Day Long Field Trip to Potrero Hills, Lodi, Stockton, Sunol and Hayward.	Colwell

8:00	Field Study of Aerial and Space Photos of Potrero Hills Anticline.
9:00	Field Study of Dryland Agriculture, Vegetable Crops and Vineyards.
10:00	Coffee Break.
10:15	Study of Orchard Crops and Urban Development.
12:00	Lunch.
1:00	Study of Thermal Infrared and Radar Imagery (Part I).
3:00	Coffee Break.
3:15	Study of Thermal Infrared and Radar Imagery (Part II).
5:00	Return to Berkeley.

7:00 No-Host Dinner at Spengers Restaurant in Berkeley

Friday, November 11, 1977 124 Mulford Hall/260 Space Sciences Lab

8:00	Optical and Electronic Enhancement of Remote Sensing Imagery.	Katibah
9:00	Use of Densitometer, Adcol and VP-8 Image Analyzer.	Colwell
10:00	Coffee Break.	
10:15	Computer Assisted Analysis Techniques.	Daus
12:00	Lunch.	
1:00	Demonstration of User-Interactive Display and Data Manipulation Terminal and IGOR.	Daus
2:15	Socio/Economic Implications of the Use of Remotely Sensed Data.	Sharp
3:00	Coffee Break.	
3:15	Course Summary.	Welch, Colwell and Daus
4:00	Quiz.	
5:00	Adjourn.	

Thursday, November 17, 1977 260 Space Sciences Laboratory

12:00 -	Use of User-Interactive Display and Data Manipulation	Daus
5:00 -	Terminal	

III. Biographical Information

Following are brief biographical sketches of the RSRP personnel involved to a major extent in the proposed course.

HAWAII - REMOTE SENSING WORKSHOP

2nd WEEK - NOVEMBER 14-18

AT AMES RESEARCH CENTER

MOFFETT FIELD, CALIFORNIA

MONDAY, NOVEMBER 14:

8:30 A.M.	Welcome to Ames Research Center - ARC Center Director
9:00 A.M.	General overview of weeks activities
9:45 A.M.	BREAK
10:00 A.M.	Introduction to computer processing of Landsat Imagery - Editor - Video Interactive Systems IDIMS System 101 Image 100 ETC.
12 NOON	LUNCH
1:00 P.M.	Introduction to Hardware - Editor - Interactive Image Display System
3:30 P.M.	Tour Data Facility
4:30 P.M.	Adjourn for Day

TUESDAY, NOVEMBER 15

8:30 A.M.	Preprocessing of Landsat Image Tapes prior to Computer Classification - Image Registration - Geometric Correction - Control Points - Noise in data - Clouds - Training Set Selection
(9:45 - 10:00	BREAK)
11:00 A.M.	General Discussion
11:30 A.M.	LUNCH
12:45 P.M.	Laboratory Demonstration of morning session
4:30 P.M.	Adjorn for Day

WEDNESDAY, NOVEMBER 16

8:30 A.M. The Editor Image Analysis System
How to Use it
(Detailed Discussion of Afternoon's Activity)

(9:45 - 10:00 A.M. BREAK)

11:30 A.M. LUNCH

12:45 Laboratory Demonstration and Hands-on Training

- Logging on
- Selection of Window
- Establishing Spectral Signatures
- Clustering (unsupervised)
- Guided Clustering
- Editing Spectral Signatures
- Classification of Window
- Display of Classified Window

THURSDAY, NOVEMBER 17

8:30 A.M.	The Interactive Image Display System	
		How to Use it
(9:45 - 10:00 A.M.	BREAK)	
10:00 A.M.	Demonstration	
		Sample Problem
11:30 A.M.	LUNCH	
2:00 P.M.	University of California - Berkeley	
		Demonstration of Image Analysis System
4:30 P.M.	Adjourn for Day	

FRIDAY, NOVEMBER 18

8:30 A.M.	Post Landsat Image Classification Analysis	
		- Data Aggregation
		- Displays
		- Classification Accuracy
(9:45 - 10:00 A.M.		BREAK)
11:30 A.M.	LUNCH	
12:45 P.M.	Wrap-up Session	
		- Critique
		- Additional Training
		- Other?
2:30 P.M.	Tour of Ames Research Center	
~~6:00 P.M.~~	~~Final Banquet~~	

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Wood for Seniors Project

SUMMARY REPORT

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

SPONSORED BY

NASA AMES RESEARCH CENTER

SUBMITTED BY:

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USER ASSISTANCE
WESTERN REGIONAL APPLICATIONS PROGRAM

AUGUST 1978

IN COOPERATION WITH CALIFORNIA'S NORTHWEST COUNTIES

4521

TRIP REPORT

MONTANA TRAINING PROGRAM

Montana State University
Bozeman, Montana

Dates: June 12-15, 1978

Persons Attending:

John Andrews	Montana Department of Natural Resources & Conservation
David W. Armstrong III	Montana Department of Agriculture
Steve Aster	Montana State University
Ray Breuninger	Montana Department of Natural Resources & Conservation
George Cawlfield	Montana Department of Natural Resources & Conservation
Robert A. Clark	Montana Department of Natural Resources & Conservation
R. Thomas Dundas, Jr.	Montana Department of Community Affairs
Ray Gavlak	Department of Plant & Soil Science, Montana State University
Randy Holm	Montana Department of Community Affairs
Brian Long	Division of Forestry, Montana Department of Natural Resources & Conservation
John E. Montgomery	Cascade County Planning
Val Morgan	Revenue - Property Assessment
Larry C. Munn	Department of Plant & Soil Science, Montana State University
Gary Rogers	Montana Department of Community Affairs
John E. Taylor	Range Science Department, Montana State University
Philip Threlkeld	Montana Department of Natural Resources & Conservation

NASA-Humboldt State University Foundation Attending·

Don Card
Bob Wrigley
Robin Welch

Materials Provided:

Class notes
Landsat photographs, approx. SE ¼ frame of Scene Nos. 1790-17354 of 21 September 1974
U-2 photographs, Flight #72-125, Frame Nos. 1753, 1754, 1755, 1756 of 26 July 1972

Materials Provided (Continued)

Black & White photographs, 1:20,000 scale, 1964-65, Frame Nos. NE-4FF-191, 192, 193; CXK-8EE-20, 21, 22; CXK-2EE-89, 90, 91; CXK-1EE-96, 97, 98

Textbooks:

Remote Sensing: A Better View - Robert D. Rudd
Everyone's Space Handbook - Dick Kroeck
Remote Sensing: Principles and Interpretation - Floyd Sabins (loaned for the course only)

Class Schedule:

Classroom lectures and field trips related to exercise on photo interpretation and training site selection in the Galatin Valley area were given. (See attached Class Schedule.)

Students were given a land-use classification exercise using a multistage photo interpretation approach with Landsat, U-2 and conventional black-and-white aerial photography. A preliminary field trip was made for familiarization with various environmental classes in the exercise area. Photo interpretation was performed for selecting computer training sites and classifying land-use in selected field sites.

A follow-up field trip was made for the purpose of verifying laboratory interpretations and collecting ground truth data.

Travel Arrangements:

Travel to and from Bozeman was by private aircraft. All class materials, texts and data products were carried in the aircraft. A photo and observation flight was made to Flathead Lake, Montana, for data collection in preparing for the Montana Department of Fish and Game training course to be given August 22-25, 1978 at Yellow Bay Biological Station, University of Montana (Flathead Lake).

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California
94035

NASA

TRAINING FOR
MONTANA REMOTE SENSING DEMONSTRATION PROJECTS

Conducted at

MONTANA STATE UNIVERSITY
Bozeman, Montana

June 12-16, 1978

by

Montana State University

Humboldt State University
Arcata, California

NASA - Ames Research Center
Moffett Field, California

Introductory Material for

AGENDA--TRAINING FOR MONTANA DEMONSTRATION PROJECTS

to be conducted at

MONTANA STATE UNIVERSITY
Bozeman, Montana

June 12-16, 1978

by MSU Staff and Personnel of
NASA-Ames Research Center
Moffett Field, California

Basic Plan

Cover or review background, theory and basics of both visual photo interpretation (PI) and digital data analysis.

Develop three or four laboratory problems for PI analysis of state-of-the-art photographic LANDSAT imagery and aerial photo stereo models from within the same area. Include some field time in the laboratory exercises.

Training Objectives

Prepare demonstration project personnel to step into more detailed training in computer analysis techniques at NASA-Ames in July, and to understand the basic procedures so they can learn other systems of digital analysis.

Give enough training in visual interpretation, ground truth and verification methods so that trainees can independently handle these support activities and use visual interpretation methods when appropriate.

Provide a good appreciation and understanding of remote sensing as an integrated system of materials and techniques.

Anticipated Spectrum of Participants

Participants will probably include both administrative-management or decision makers and technical or support staff persons. In addition, MSU has requested participation by up to six professors who are in a position to include or strengthen remote sensing elements in their university courses.

Demonstration Projects

Three of the four demonstration projects specifically mention an aerial photo and photo interpretation element in the project plan. All projects specify one or more levels of information that may be most feasibly obtained from aerial photography. In addition to this, we wish to always convey the philosophy that the most effective use of LANDSAT imagery, whether by visual PI or digital analysis, is realized when some conventional aerial photography support is available as an information source.

The four demonstration project proposals also list subjects of interest where the most feasible approach is through an initial visual interpretation and stratification of the LANDSAT images followed by in-depth computer analysis. Thus, this training program has been planned with the idea of covering or reviewing, as necessary, the fundamental principles of visual interpretation and giving an opportunity through laboratory exercises to rather completely simulate, through visual image analysis, what will subsequently be done by digital computer analysis in the ARC follow-on training sessions and in the demonstration projects themselves.

Follow-on Workshops

Subsequent to this training session, follow-on workshops for smaller groups will be conducted at the NASA-Ames Research Center to provide specific in-depth training in appropriate software systems for LANDSAT data analysis. The laboratory problems for the in-state training session include the southern scene area of the demonstration projects. As such, its visual analysis will provide valuable background for some of the more detailed work to be carried out at Ames. In summary, then, THE GOAL of the in-state training session is to carry out their roles in ensuring success of the demonstration projects and, at the same time, to prepare a smaller technical staff of analysts to move successfully through the intensive training at Ames.

The agenda for the in-state training session at Montana State University, Bozeman, is shown in the accompanying table.

MONTANA DEMONSTRATION TRAINING PROGRAM

AGENDA

Time	Subject	Instructor
MONDAY, June 12:		
9:00 a.m.	Welcome to MSU	Professor Ted Williams Interim Vice President for Research
9:15 a.m.	Course Introduction	C. E. Poulton
9:30 a.m.	Remote Sensing, What It Is	C. E. Poulton
9:40 a.m.	Generalized Work Flow in Remote Sensing	C. E. Poulton
10:00 a.m.	Coffee Break	
10:15 a.m.	Basic Physics, Matter and Energy	R. I. Welch
12:00 Noon	Lunch	
1:00 p.m.	Remote Sensing Systems	R. I. Welch
1:50 p.m.	Visual Image Interpretation, Basics and Principles	J. M. Ashley
3:00 p.m.	Coffee Break	
3:15 p.m.	Image Familiarization and Two Interpretation Exercises with Discussion and Illustration of Principles ' Complete formal coverage of principles, photo geometry and methods of interpretation with hands-on perusal of LANDSAT 1:250,000, 1:1,000,000, U-2 CIR 1:120,000, B&W 1:20,000	J. M. Ashley
7:00 p.m.	Purdue Self-Learning Slide-Tapes Available for Independent Review and Study	

Time	Subject	Instructor
TUESDAY, June 13:		
8:00 a.m.	Field Laboratory - Three Forks Area, Work with Aerial Photography, Highflight CIR, Satellite Image CIR	Staff
	Weather Permitting, Discuss Legend, Mapping and Ground Truth Methods	C. E. Poulton
	Any Necessary Wind-up on PI Procedures	J. M. Ashley
12:00 Noon	Lunch, Brown Bag to Field	
1:00 p.m.	Numerical Analysis of MSS	C. E. Poulton
2:00 p.m.	Digital Analysis Flow, Input-Output Functional Capabilities, Hardware, Software	R. C. Wrigley
3:10 p.m.	Coffee Break	
3:25 p.m.	Steps and Alternatives in Digital Data Analysis	R. C. Wrigley
7:00 p.m.	Purdue Self-Learning Slide-Tapes Available for Independent Review and Study	
WEDNESDAY, June 14:		
8:00 a.m.	Conclude Steps and Alternatives in Digital Data Analysis	R. C. Wrigley
9:00 a.m.	Screening and Ordering of LANDSAT	C. E. Poulton
9:30 a.m.	Roles of Various Groups in Advice and Assistance	C. E. Poulton
9:50 a.m.	Coffee Break	
10:15 a.m.	Initiate Comprehensive Lab Work, LANDSAT Stratification and Interpretation in Multistage Mode using Highflight CIR and Conventional B&W Aerial Photography for Support	Staff

Time	Subject	Instructor
WEDNESDAY, June 14 (Continued)		
12:00 Noon	Lunch	
1:00 p.m.	Laboratory Problem with LANDSAT Stratification and Interpretation -- Continue with Discussion and Questions to Staff	Staff
7:00 p.m.	Purdue Self-Learning Slide-Tapes Available for Independent Review and Study	
THURSDAY, June 15:		
8:00 a.m.	Mathematics and Statistics of Classification and their Intepretation	D. H. Card
	Statistical Sampling, Multistage and Multidate Methods	D. H. Card
	Statistical Verification of Classification	D. H. Card
10:00 a.m.	Coffee Break	
10:15 a.m.	Laboratory Problem, Working with Line Printer Data and Statistics--Probably Based on Spokane Windows	R. C. Wrigley & D. H. Card
11:30 a.m.	User Awareness Interview - Explanation and Scheduling Interviews through Afternoon	P. L. Williams
12:00 Noon	Lunch	
1:30 p.m.	Continue Lab Exercise with Discussion and Questions & Answers to Staff	R. C. Wrigley & D. H. Card
7:00 p.m.	Purdue Self-Learning Slide-Tapes Available for Independent Review and Study	

Time	Subject	Instructor
FRIDAY, June 16:		
8:00 a.m.	Field Verification of LANDSAT Stratification Interpretation and Training Area Selection Exercise	Staff
12:00 Noon	Lunch, Brown Bag to Field	
1:00 p.m.	Wrap-up Discussion - Evaluation of Laboratory and Field Problems - Clear up any Questions these Exercises may have Raised	Staff
3:00 p.m.	Plans and Schedule for Follow-on Training	R. C. Wrigley
3:30 p.m.	End	

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Basic Subject Matter Outline -- Remote Sensing Applications

The staff at NASA-Ames Research Center is in the process of developing a comprehensive outline of the information that people need to know when embarking on a LANDSAT or other related remote sensing demonstration project. Our present draft of this evolving outline follows.

It is intended that this outline will be beneficial to you as a preview of most of the topics that will be discussed or demonstrated in this training session. As you compare it to the agenda, you will note that the order is sometimes changed to accommodate available blocks of time and the schedules of the instructors. You will also notice that all of the topics in the outline are not included in this short-course. We have selected those that available time and the nature and goals of your four demonstration projects allow. We hope that time will confirm that we have made an acceptable compromise.

While you can find an endless variety of views on how the learning of essential remote sensing background and technological skill should proceed, we feel this outline does have a highly practical or operational orientation and that you will find it of some use in your own program of supplemental reading, study and self-learning. We hope that this course will have given you the necessary review and the essential new knowledge to start you on the road to complete success and satisfaction with your individual roles in the Montana Demonstration Projects.

If, near the conclusion of the course, you have suggestions for the improvement of this outline, they will be received with appreciation and be given serious consideration as future iterations are prepared.

11 May 1978; CEP
w/contributions by
Briggs & Wrigley

A SUBJECT MATTER OUTLINE

Potential Information for Inclusion in Remote Sensing Courses or Curricula

1. General Introduction (specific to each training course)
   - 1.1 Summary, discipline and information needs, user interest orientation
   - 1.2 Goals and objectives
   - 1.3 Scope, content and instruction methods
   - 1.4 Course agenda and time table
2. Remote Sensing; What it is, the Integrated System Concept
3. The Basic Physics of Remote Sensing, Matter and Energy Relationships
   - 3.1 The electromagnetic spectrum and remote sensing windows
   - 3.2 Physical concepts and theory
   - 3.3 The spectral basis of remote sensing
4. Remote Sensing Systems, Photographic and Imaging; Active and Passive; Characteristics, how function; Advantages and Limitations; Examples
   - 4.1 Photographic sensors
   - 4.2 Multispectral scanners; airborne, satellite borne
   - 4.3 Side-looking airborne radar, SLAR
   - 4.4 LANDSAT return beam vidicon, RBV
   - 4.5 Thermal, heat capacity mapping
   - 4.6 Future systems, refinements and modifications
5. Generalized Work Flow in Remote Sensing Applications, Design of an Integrated System for Information Acquisition, the Multi-concepts
6. Determination of Information Classes
   - 6.1 Ground truth methods and data/information requirements
   - 6.2 Legend development techniques and guidelines--Taxonomic Legend--hierarchical vs. single level; methods of formulation
   - 6.3 Mapping and cartographic concepts--Mapping Legend--delineation, identification, information transfer techniques

7. Concepts and Principles of Interpretation and Analysis
   - 7.1 Visual image interpretation
     - 7.11 Photo and image geometry; scales, displacement and mensuration
     - 7.12 Problems of displacement, geometric and spectral correction
     - 7.13 Criteria and methods of visual interpretation; stereo viewing; tone, color, texture, etc.; convergent and associated evidence; enhancement; densitometry; comparative analysis
     - 7.14 Photo interpretation keys and aids
     - 7.15 Special techniques for CIR, thermal and multispectral imagery--aircraft and LANDSAT
   - 7.2 Numerical analysis of multispectral data--basic theory
     - 7.21 Classification in multidimensional space, basic theory
     - 7.22 Supervised vs. unsupervised approaches
     - 7.23 How ground knowledge, conventional data sources and supporting imagery are used
     - 7.24 Nature of computed results and output products

8. Digital Analysis Systems and their Effective Use
   - 8.1 Flow of analysis, input to output; generic and for typical applications, e.g., forestry, range, water, agriculture
   - 8.2 Functional capabilities of hardware, overview
     - 8.21 Interactive systems
     - 8.22 Batch systems
     - 8.23 Digitizers and plotters
   - 8 3 Functional capabilities of software, overview and examples
     - 8.31 IDIMS and System 101
     - 8.32 TENX EDITOR and ILLIAC
     - 8.33 VICAR/IBIS
     - 8.34 ERL/SEC-32
     - 8.35 LARSYS
     - 8 36 Other
     - 8.37 Comparative strengths and weaknesses

9. Steps and Alternatives in Digital Analysis
   - 9.1 Preliminary processing and correction, preprocessing for analysis
   - 9.2 Training the classifier
     - 9.21 Selection of training sites
       - 9.211 Criteria (size, spectral character)

9. Steps and Alternatives in Digital Analysis (Cont'd)

9.2 Training the classifier (Cont'd)

9.21 Selection of training sites (Cont'd)

9.212 Methods (trackball, random, uniformity, line and sample)

9.213 Use of photographs and LANDSAT images

9.22 Clustering of training sites

9.221 Important parameters (std. max., number classes, iterations, min. number pixels, etc.)

9.222 Comparison of clusters (compare, diverge)

9.223 Combine and delete clusters (criteria--size, area, fit to information classes, etc.)

9.23 Covariance matrix, meaning and interpretation

9.24 Other statistics, meaning and interpretation

9.3 Classification methods

9.31 Parallelepiped

9.32 Minimum distance

9.33 Maximum likelihood (LARS Bayesian)

9.4 Verification of classified image(s)

9.41 Determining general accuracy, correctness of classification

9.42 Detailed comparison with photos, maps and ground data

9.43 Identification and specification of classification problems

9.5 Correcting and refining image classification

9.51 Retraining bad classes, recluster and reclassify

9.52 Change class names via stratification

9.6 Summation of classification by:

9.61 Administrative boundaries (counties, districts, census tracts, etc.)

9.62 Ecological boundaries (forest or range types, watersheds)

9.63 Geographical boundaries (townships, quads, sections, etc.)

9.7 Statistical verification of final classification

9.71 Simple (photo checks, aerial overflight, use of ground data, maps and tabular summaries

9.72 The concept and use of error matrices

9.73 Rigorous random/stratified random sampling, calculation of errors and confidence limits at specified probabilities

9.8 Evaluation of products by user agencies

9.81 Comparison with normal methods

9.82 Cost factors, timeliness of data, etc.

9.83 Additional utility of results, unanticipated benefits

10. Practical Use of Image Analysis Systems; System Specific; Developing Skills, Hands-on Practice and Job Instruction Training
    - 10.1 Visual interpretation
        - 10.11 Course-connected laboratory problems
        - 10.12 Workshop, Job Instruction Training with project imagery
        - 10.13 Procedural manuals
    - 10.2 Digital analysis and visual-digital interactive analysis
        - 10.21 Workshop, Job Instruction Training with project data, generally emphasize IDIMS and EDITOR
        - 10.22 On-the-job follow-up of training
        - 10.23 User manuals

11. Additional Training Elements as Appropriate to Project or Agency Need
    - 11.1 Project planning and design
        - 11.11 Problem analysis
        - 11.12 Definition of information needs/user requirements and specify end products
        - 11.13 How and by whom will information be used in action program
        - 11.14 Choice of remote sensor or combinations needed, conventional and sophisticated systems as appropriate
        - 11.15 Need and specifications for monitoring and feedback in management
    - 11.2 Sampling and multistage (multiscale) methodologies
    - 11.3 Interpretations of classification statistics
    - 11.4 Multidate and change detection methodologies
    - 11.5 Guidance for further education and self-learning

12. Image/Data Acquisition
    - 12.1 Screening, specifying and ordering LANDSAT, how to use the browse file
    - 12.2 Requesting high-flight products; existing, new imagery
    - 12.3 Planning a photo mission
    - 12.4 Quality control of products and specialized image processing
        - 12.41 Photo and color balance manipulation
        - 12.42 State-of-the-art image products from LANDSAT for visual interpretation

13. Computerized Data Base and Information Management
    - 13.1 Specification of information needs for decision process
    - 13.2 Data reduction and synthesis
    - 13.3 Polygon vs. cell systems of storage
    - 13.4 Strengths and uses of computer mapping from a stored data base
    - 13.5 Compatibility of LANDSAT with computerized data base concept

14. Remote Sensing Equipment and Facilities Requirements
    14.1 A basic functional laboratory
    14.2 Graduated development of capability
    14.3 Full capability options

15. Application Examples; Successful Uses of Remote Sensing Technology, Stressing Concepts, Approaches and Project Design
    15.1 Single discipline
    15.2 Multidiscipline applications
    15.3 Summary--scope/limitations/accuracy considerations in use of LANDSAT

16. Roles of Various Groups in Technology Transfer, Advice and Assistance
    16.1 Federal agencies; NASA, EROS, USGS/NCIC, other
    16.2 Educational institutions; universities, state colleges, community colleges, cooperative extension, continuing education
    16.3 The growing role of industry and consultants

17. Discuss and Brainstorm Specific User Interests and Needs, Formulate Initial Concept of Remote Sensing Systems to Meet Requirements for Solving Specified Problems

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Summary

Montana Demonstration Projects

1. Title: Montana Dam Inventory Demonstration Project
   Gallatin-Park Region

   User Agency: Department of Natural Resources

   Objective: To demonstrate the feasibility of using computer-aided analysis of LANDSAT digital imagery along with photo interpretation to locate reservoirs by Section, Township, and Range, and to estimate the approximate surface area of the reservoirs.

2. Title. Cascade County Land Resources Inventory

   User Agency: Multi-Agency participation

   Objective: To demonstrate the feasibility of using computer-aided analysis of LANDSAT digital imagery for obtaining land use and land cover information.

3. Title: Remote Sensing of Agriculture
   Gallatin-Park Region

   User Agencies: Department of Natural Resources, Department of Revenue, Department of Agriculture, and Montana State University

   Objective: To demonstrate the feasibility of using computer-aided analysis of LANDSAT digital imagery along with photo interpretation for obtaining land use and land cover information. Particular emphasis is on land use and land cover change.

4. Title: Gallatin-Park Region Timber Demonstration

   User Agencies: Department of Natural Resources, Department of Revenue, Department of Agriculture, and Montana State University

   Objective· To demonstrate the feasibility of using computer-aided analysis of LANDSAT digital imagery along with photo interpretation for obtaining information on forest cover, identification of forest types, forest condition and quality.

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Lesson Plan Module

1.00 COURSE INTRODUCTION

1.10 Summary: This section of each course is individualized for the specific requirements of each participating group and to the physical setting in which instruction is being done.

The brief explanatory session will cover any necessary protocol and provide general instructions as regards accommodations, working procedures, course scope and objectives for completing the agenda.

1.20 Goals and Objectives: Provide an orientation that will insure effective interaction between trainees and instructors, and insure success of the short course.

1.30 Introduce instructional staff. Self-introduction of trainees. Hand out instructional materials and notebooks.

Explain mini-course materials available for supplemental learning experiences.

1 40 If agenda items need clarification or emphasis, these will be covered as needed.

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Background of Remote Sensing

Master Outline Category: 2.00

Category Title: Remote Sensing, What It Is

Module Title: Remote Sensing as an Integrated System for Acquiring Useful Information About Earth Resources

Goals and Objectives:

To bring trainees to a common understanding and appreciation of remote sensing as an integrated system of technologies from aerial photography to satellite imagery.

To provide an appreciation of the development of remote sensing technology and to present certain essential definitions and concepts upon which the remainder of the training course will be based.

Rationale and Summary of Content:

Some definitions and concepts of remote sensing tend to fragment the technology into seemingly unrelated or incompatible components. This tends to create an either-or confrontation in the selection of components and the design of remote sensing systems to solve practical earth resource problems.

Many people, being unfamiliar with satellite imagery, tend to discount its usefulness without appreciation of the characteristics, limitations and advantages of the data--without understanding its role and potential uses in consort with conventional methods.

Remote sensing is defined as an integrated system and its multiple elements and key concepts are explained to provide a rational clarification of the above points.

Prerequisite Knowledge and Understanding:

This course is predicated on the assumption that training will have to start with a review of the basics of conventional photo interpretation, but that most participants will have attended the two-day seminar held in Helena, Montana on 24-26 January 1978.

Essential Elements Presented:

1. Definition of remote sensing.

2. Primary goal in the use of remote sensing

3. A few key turning points in development of present technology.

4. Candidate systems suited to Montana Demonstration projects.

5. The role and requirements for ground knowledge.

(slide) 6. The multi-concepts.

(slide) 7. The integration of management function, information need and most suitable scale and system.

8. The integrated multistage sampling concept.

References:

Rudd, Remote Sensing a Better View, Chapter 1.

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Generalized Work Flow

Master Outline Category: 5.00

Category and Module Title: Generalized Work Flow in Remote Sensing Applications; Design of an Integrated System

Goal and Objectives:

The goal is to provide trainees with an appreciation for a step-wise flow in the design of a problem-specific remote sensing system for acquisition of information about resource characteristics, potentials, use management, and condition.

The objective is to provide an understanding of the key points essential to successful accomplishment of each step so that optimum application of remote sensing technology can be made in each demonstration project.

Rationale and Summary Statement:

The flow diagrams used as a basis for this presentation have been developed through extensive research and numerous remote sensing applications projects involving both satellite imagery and aerial photography with appropriate ground work. They have served as a pattern for the design of remote sensing projects both domestically and in four developing nations. While obviously subject to improvement, they are useful, tested models.

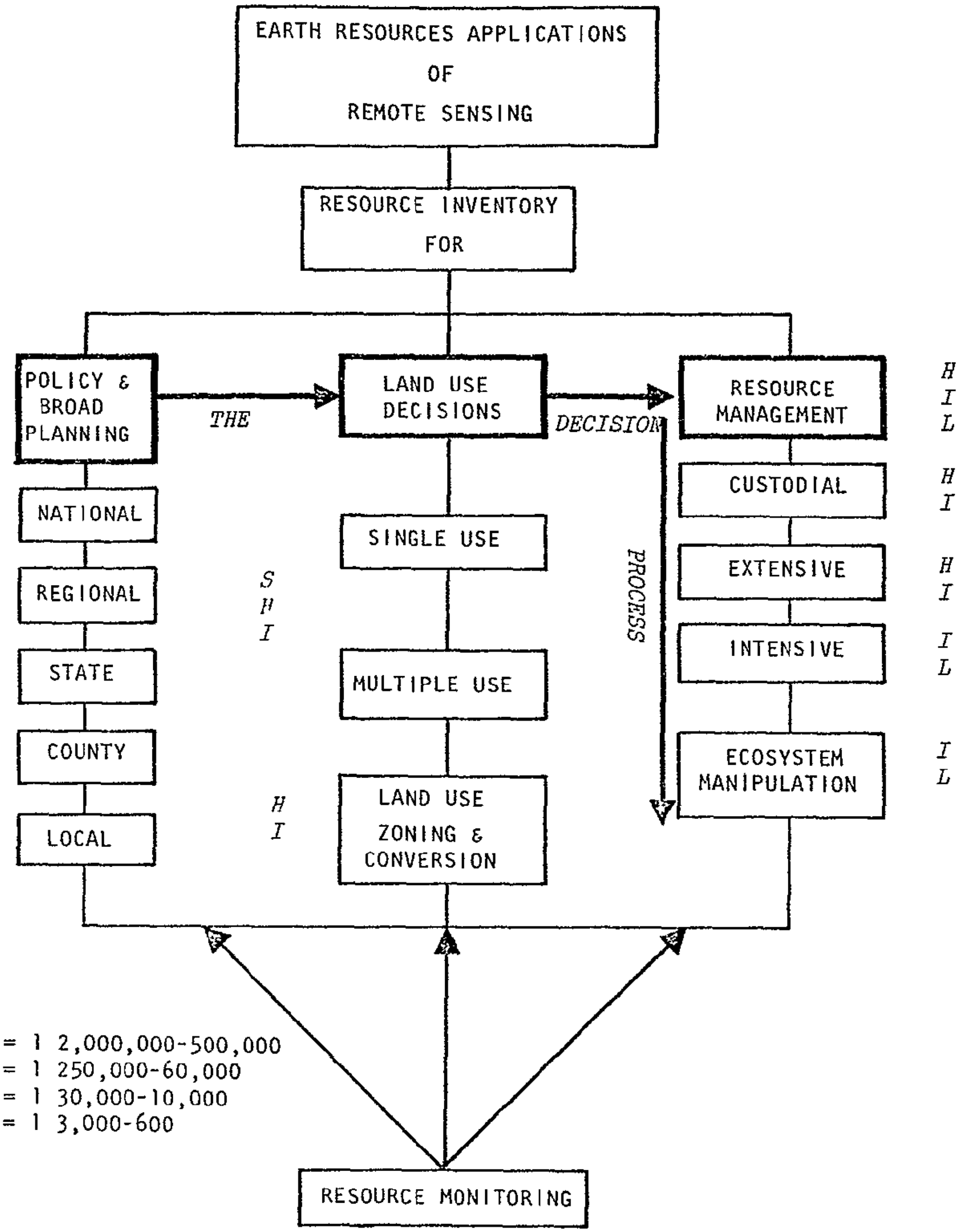
Module Content:

The presentation will be built around and explain two different but related flow charts presented in a series of slides. Hard copies on 8½ x 11" format will subsequently be provided to the trainees.

References None

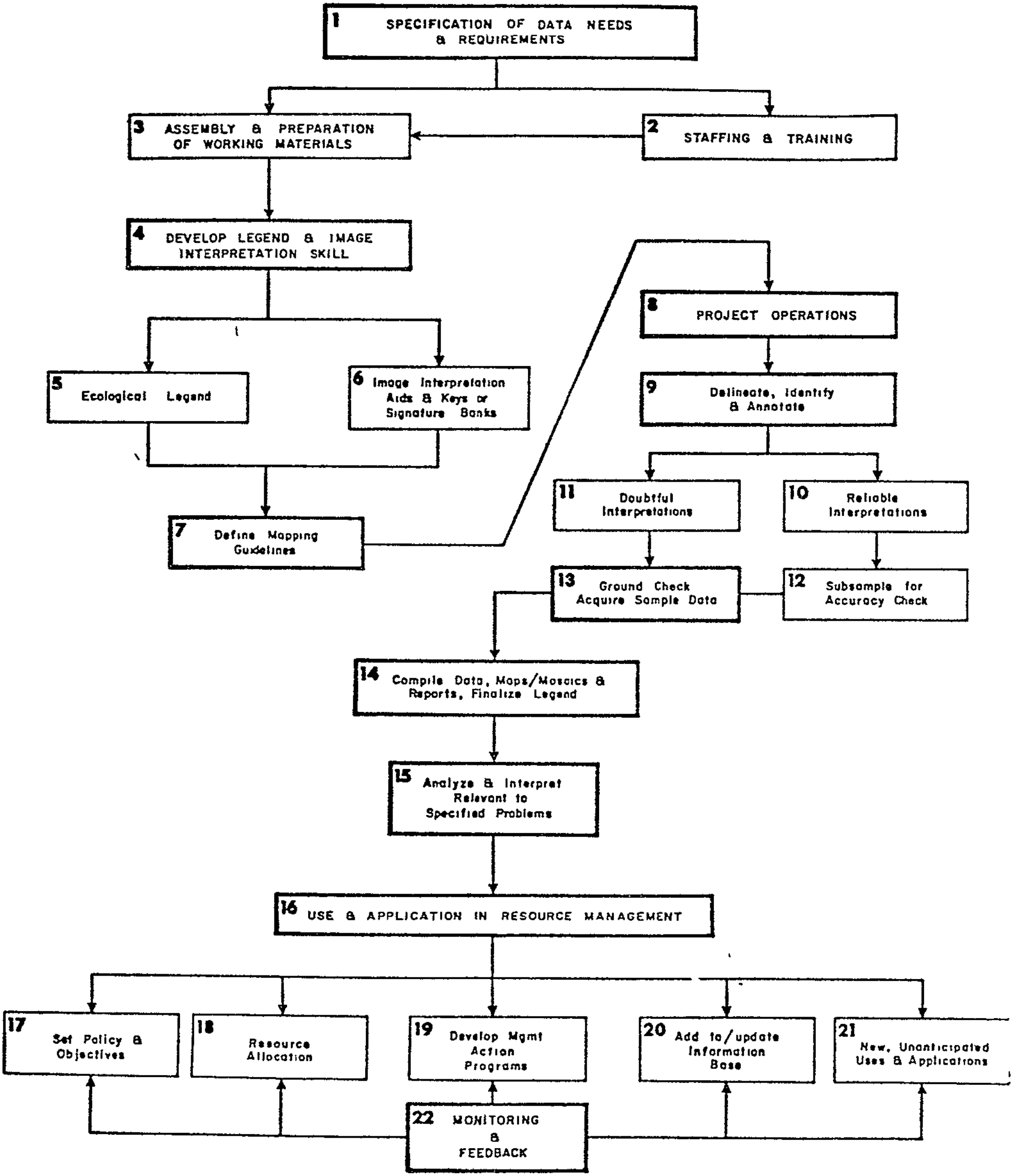
Laboratory Exercise:

It is suggested that after the training course the plan for each of the demonstration projects be re-evaluated in the light of these work flow diagrams and other knowledge gained in the short course



S = 1 2,000,000-500,000
H = 1 250,000-60,000
I = 1 30,000-10,000
L = 1 3,000-600

WORK FLOW & SCHEME FOR RESOURCE INVENTORY, ANALYSIS, & MANAGEMENT



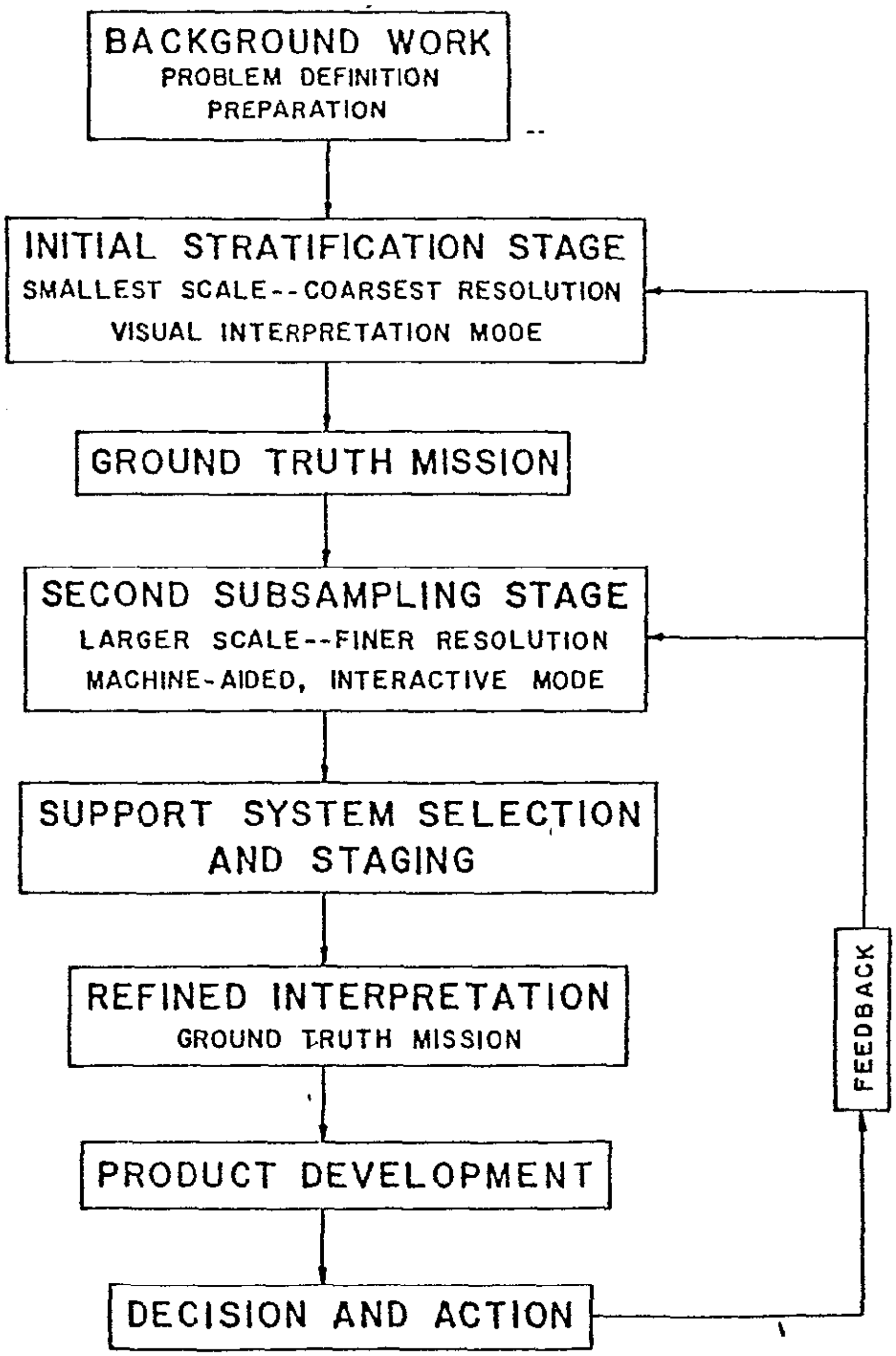


Figure 10. A generalized flow chart for an operational remote sensing system involving space acquired imagery.

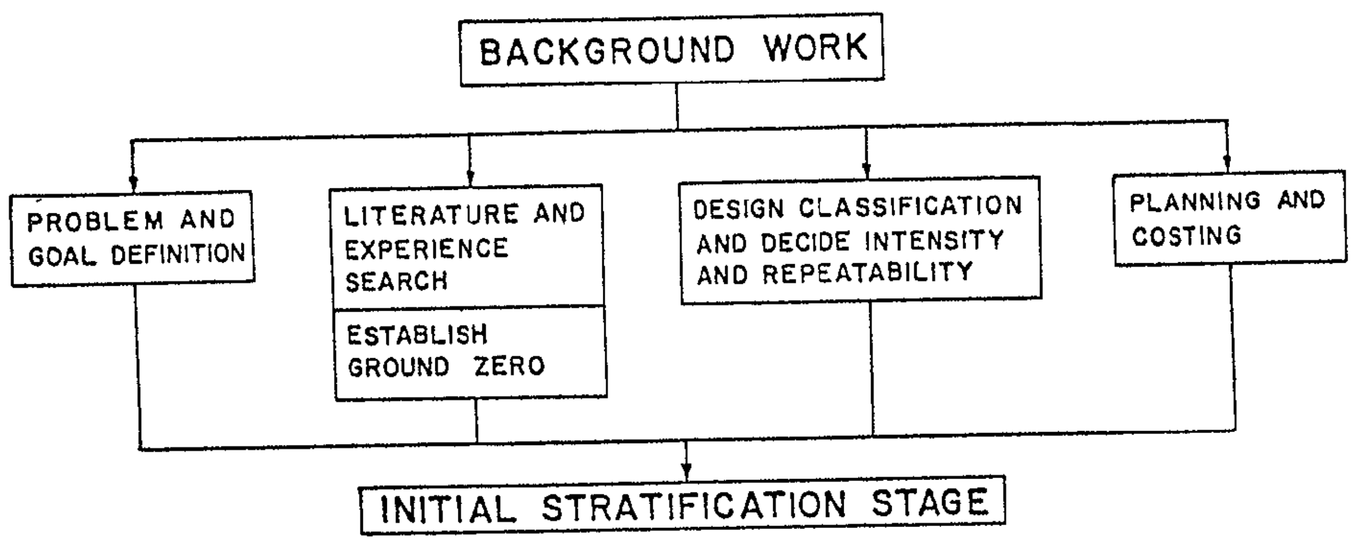


Figure 10a. Some important details of background to set the stage for effective remote sensing of earth resources subjects.

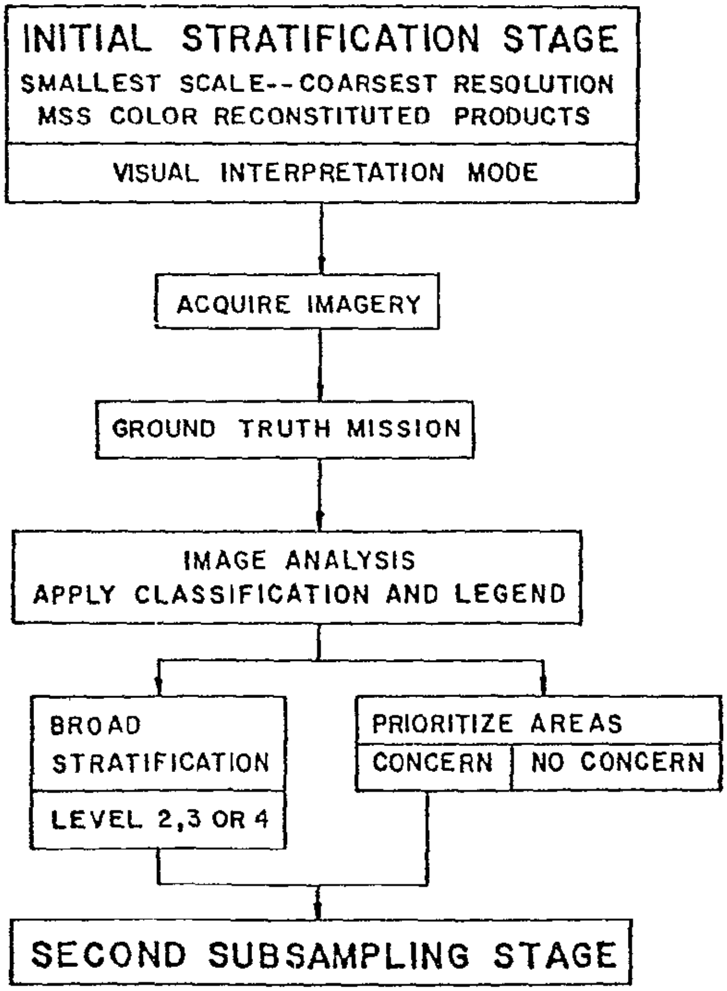


Figure 10b. The initial stratification and area priority stage of inventory.

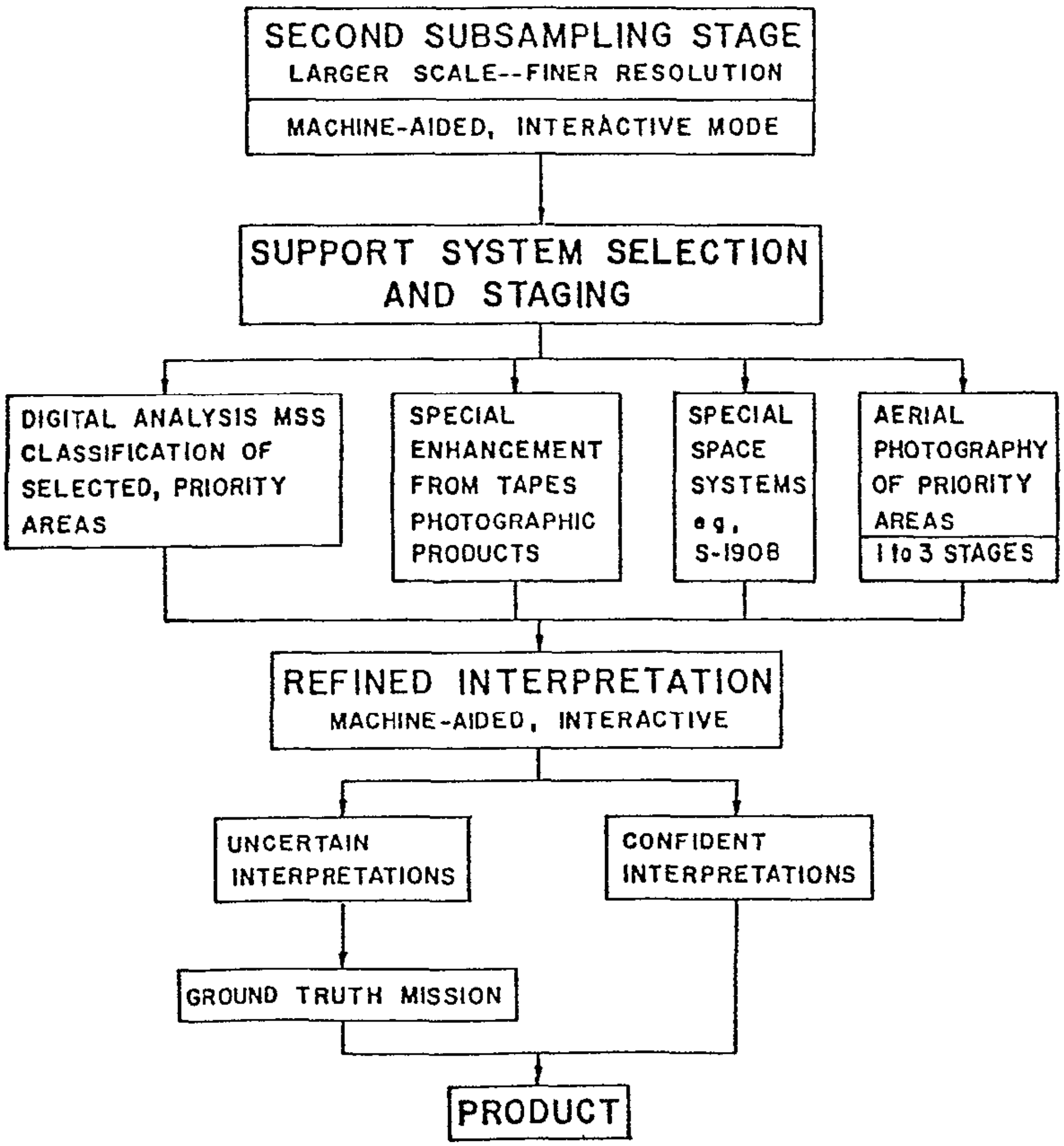


Figure 10c. The alternative selection and in-depth interpretation stage.

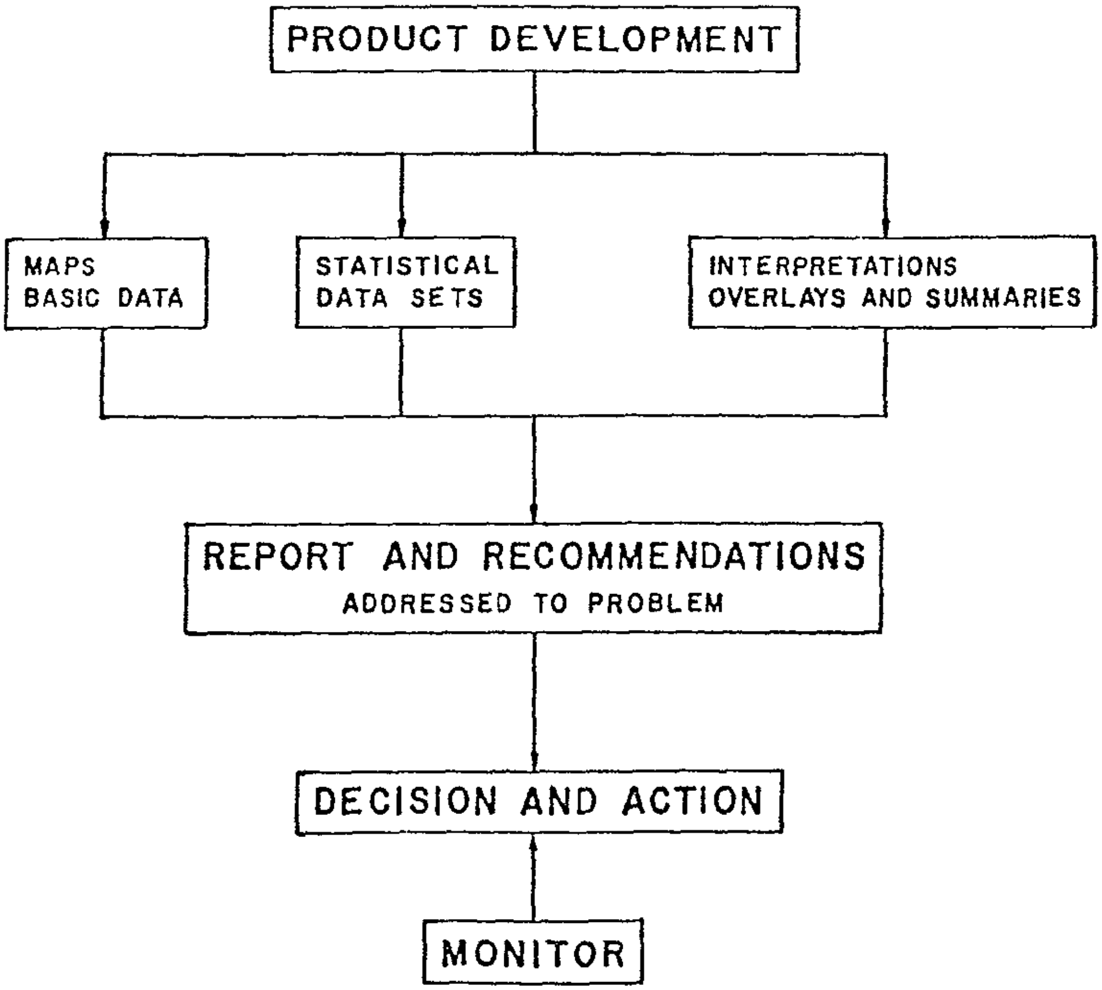
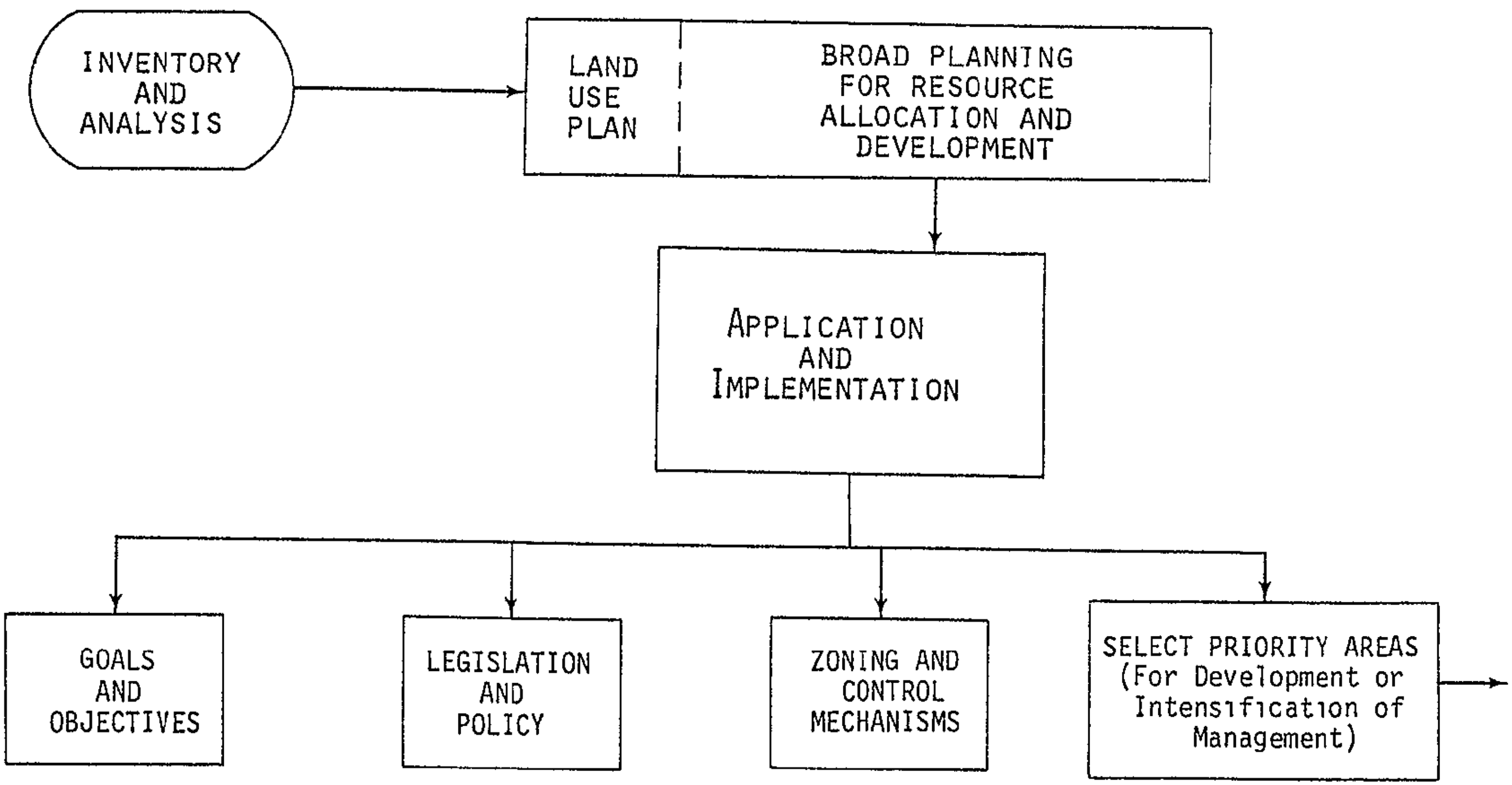
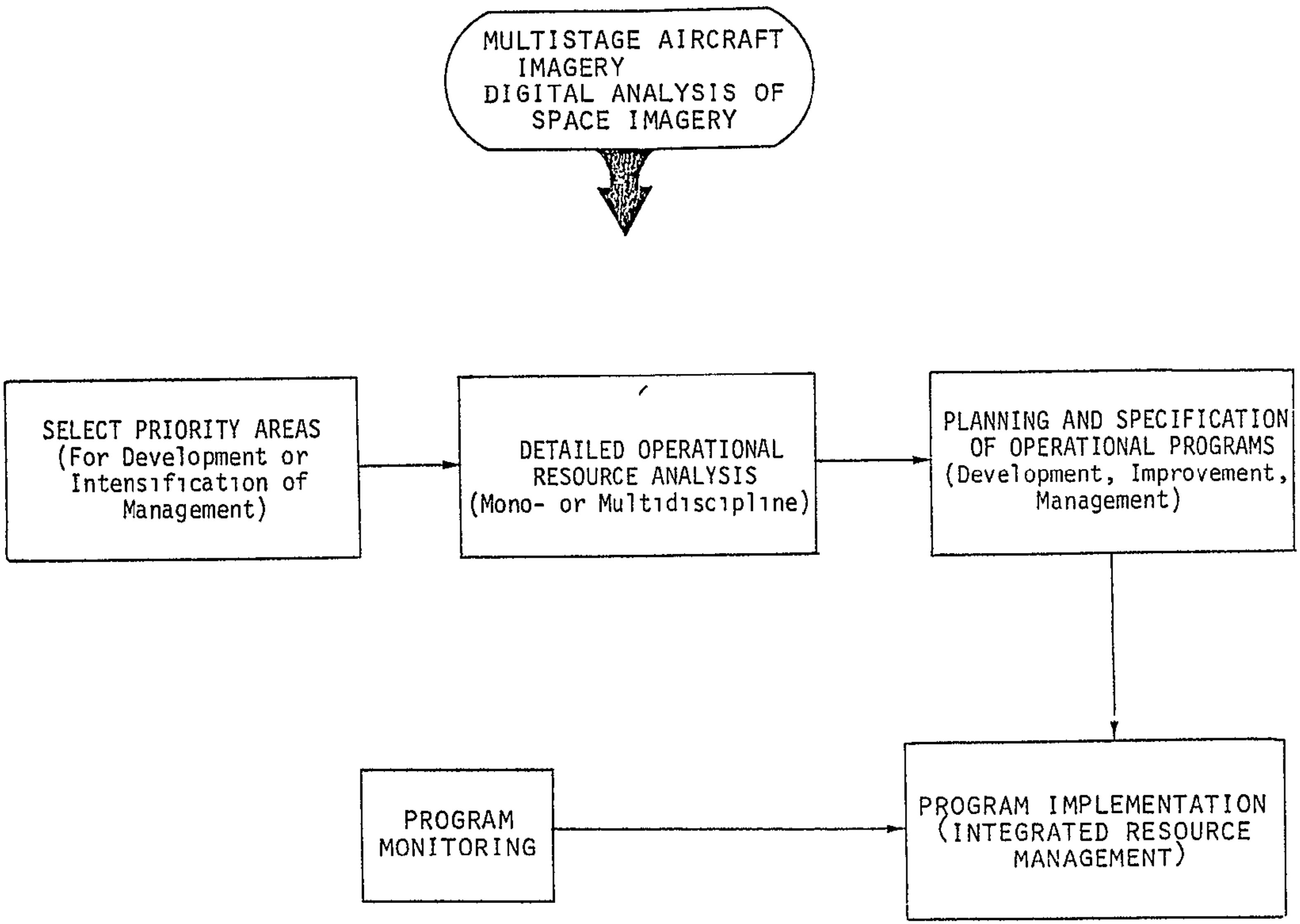


Figure 10d. The product development presentation and action stages in the use of remote sensing systems.

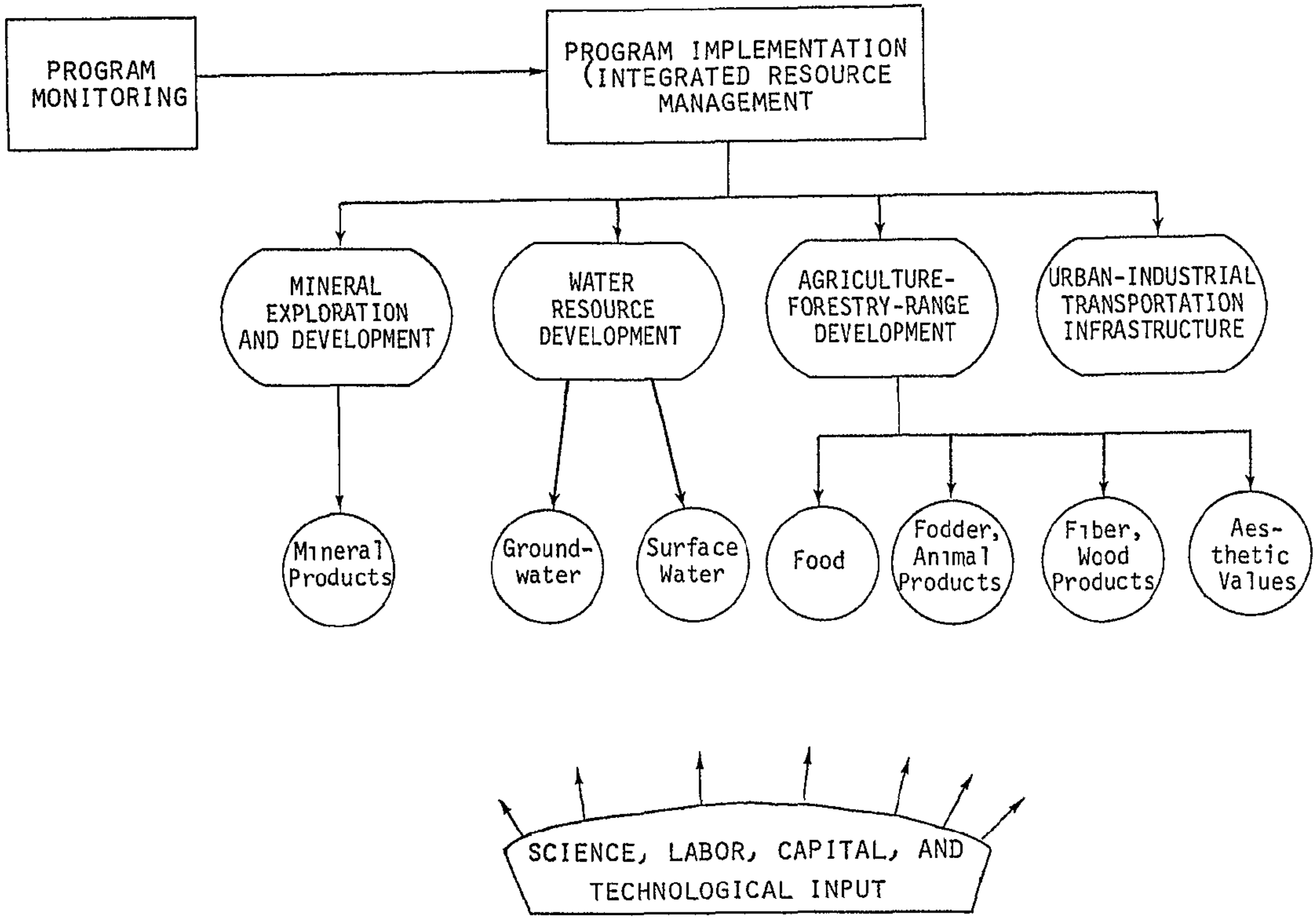
AN ECOLOGICAL APPROACH TO LAND USE PLANNING AND RESOURCE MANAGEMENT



AN ECOLOGICAL APPROACH TO LAND USE AND RESOURCE MANAGEMENT



AN ECOLOGICAL APPROACH TO LAND USE AND RESOURCE MANAGEMENT



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C-6

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Legends & Mapping Procedures

Master Outline Category: 6.00

Category and Module Title: Determination of Information Classes--Legends, Mapping and Ground Truth

Goal and Objectives:

The goal is to give the trainees an appreciation of the unique legend approaches and concepts required in use of satellite imagery along with aerial photography in a multistage or supporting role.

The objectives are to provide a working understanding of devisive and agglomerative legend development, taxonomic legends and mapping legends, mapping intensity guidelines and two legend systems that have proved successful in multistage remote sensing applications.

Summary Statement:

This module synthesizes a large amount of experience and guidelines from practical work and procedural manuals for many kinds of resource survey and inventory. It synthesizes the information in a generic or generally applicable context and concludes by presentation of two useful legend systems based on a devisive approach.

Prerequisite Knowledge:

None assumed beyond professional competence in some earth resources disciplines.

Essential Elements Presented:

1. The role and importance of ground-acquired knowledge in legend development.
2. The devisive vs. the agglomerative classification approaches.
3. Taxonomic legends.
4. Mapping guidelines and type mapping.
5. The mapping legend.

Essential Elements Presented (Continued)

6. The OSU Multistage Devisive Legend.

7. The USGS Devisive Legend System.

Key References:

Hand-out materials on Item 6.

Anderson, James R., Ernest E. Hardy, John T. Roach & Richard E. Witmer. A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper 964, United States Government Printing Office, Washington: 1976.

Poulton, Charles E. 1972. A comprehensive remote sensing legend system for the ecological characterization and annotation of natural and altered landscapes. Proc. 8th International Symposium on Remote Sensing of Environment, ERIM, Ann Arbor, Michigan, 2-6 October 1972. Pp. 393-408.

Environmental Sciences Centre
KANANASKIS
The University of Calgary.
Alberta, Canada

DEVELOPMENT AND APPLICATION OF AN ECOLOGICALLY BASED REMOTE SENSING LEGEND SYSTEM FOR THE KANANASKIS, ALBERTA, REMOTE SENSING TEST CORRIDOR (SUBALPINE) FOREST REGION)

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International Society for Photogrammetry

Banff, Alberta, Canada

October 7-11, 1974

ABSTRACT

The development and application of an ecologically based remote sensing legend system designed for multistage inventory of earth resources and land use is presented for the Kananaskis Alberta Remote Sensing Test Corridor. The symbolic legend follows a computer-compatible decimal system and devisive hierarchical logic. The system provides for treatment of natural vegetation, vegetation height and crown closure classes and lahd uses that have changed the natural landscape. Also in a fundamental ecological context, the legend system provides.for assessment of those features of the physical environment that are important in land and resource management and that may generally be identified or indexed from image features by qualified interpreters. These environmental features include: macro-relief, land-forms, surficial geology and soils. In the present study, these physical features of the landscape were not given detailed consideration. A four stage resource inventory example from the ERTS-I satellite (1·1,000,000) to 1:29,000 aircraft imagery illustrates how the natural ecological units of the landscape become the common denominator and facilitate information transfer through application of a unified legend.

A Comprehensive Ecological Legend Format

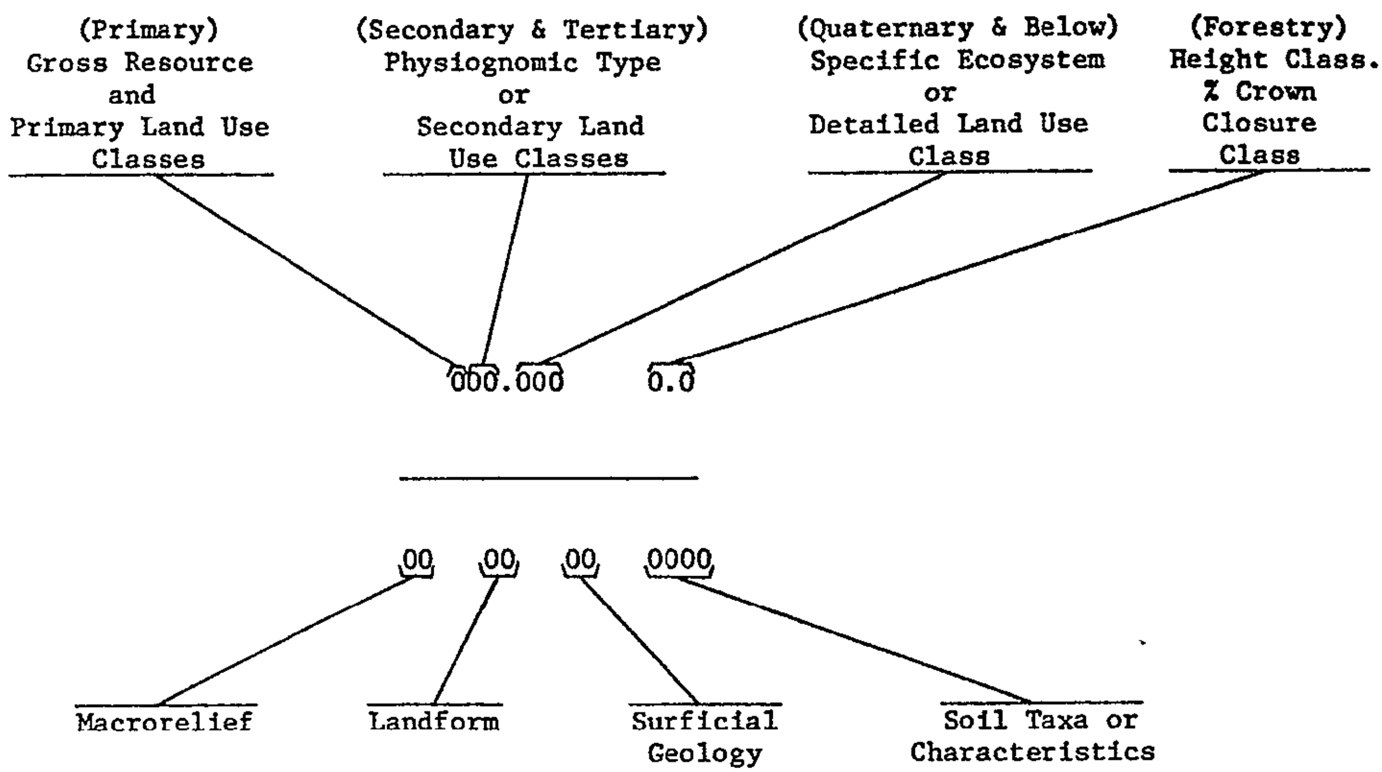


FIGURE 1. The Detailed Format for a Comprehensive Ecological Legend. The legend is designed to treat multiple natural features of the landscape as well as land use and to be computer compatible (in Poulton, 1972 modified).

TABLE I

Symbolic and Technical Legend Classes

EARTH SURFACE AND LAND-USE FEATURES

PRIMARY CLASSES

100 - BARREN LAND
200 - WATER RESOURCES
300 - NATURAL VEGETATION
400 - CULTURAL VEGETATION
500 - AGRICULTURAL PRODUCTION
600 - URBAN, INDUSTRIAL, TRANSPORTATION
700 - EXTRACTIVE INDUSTRY, NATURAL DISASTERS
800 - RECREATION AND OPEN SPACE-RELATED
900 - OBSCURED LAND

PRIMARY CLASSES

SECONDARY CLASSES

TERTIARY CLASSES

QUATERNARY CLASSES

100 - BARREN LAND
- 110 - Playas, dry, or intermittent lake basins
- 120 - Aeolian barrens (other than beaches and beach sand)
  - 121 - Dunes
  - 122 - Sandplains
  - 123 - Blowouts
- 130 - Rocklands
  - 131 - Bedrock outcrops (intrusive & erosion-bared strata)
  - 132 - Extrusive igneous (lava flows, pumice, cinder and ash)
  - 133 - Gravels, stones, cobbles & boulders (usually transported)
  - 134 - Scarps, talus and/or colluvium (system of outcropping strata)
  - 135 - Patterned rockland (nets or stripes)
- 140 - Shorelines, beaches, tide flats, and river banks
- 150 - Badlands (barren silts and clays, related metamorphic rocks and erosional wastes)
- 160 - Slicks (saline, alkali, soil structural, non-playa barrens)
- 170 - Mass movement
- 190 - Undifferentiated complexes of barren lands

200 - WATER RESOURCES
- 210 - Ponds, lakes, and reservoirs
  - 211 - Natural lakes and ponds
  - 212 - Man-made reservoirs and ponds
- 220 - Water courses
  - 221 - Natural water courses
  - 222 - Man-made water courses

PRIMARY CLASSES

SECONDARY CLASSES

TERTIARY CLASSES

QUATERNARY CLASSES

230 - Seeps, springs and wells
- 231 - Seeps and springs
- 232 - Wells

240 - Lagoons and bayous
250 - Estuaries
260 - Bays and coves
270 - Oceans, seas, and gulfs
280 - Snow and Ice
- 281 - Seasonal snow cover
- 282 - Permanent snow fields and glaciers

290 - Undifferentiated water resources

300 NATURAL VEGETATION
- 310 - Herbaceous types
  - 311 - Lichen, cryptogam, and related communities
  - 312 - Prominently annuals
  - 313 - Forb types
  - 314 - Grassland, steppe, and prairie
  - 315 - Meadows
  - 316 - Marshes
  - 317 - Bogs and muskegs
  - 319 - Undifferentiated complexes of herbaceous types
- 320 - Shrub/Scrub Types
  - 321 - Microphyllous, non-thorny scrub
  - 322 - Microphyllous thorn scrub
  - 323 - Succulent and cactus scrub
  - 324 - Halophytic shrub
  - 325 - Shrub steppe
  - 326 - Sclerophyllous shrub
  - 327 - Macrophyllous shrub
    - 327.1 - Willow *(Salix)* Predominent Vegetation
    - 327.2 - Birch *(Betula)* Predominent Vegetation
    - 327.3 - Alder *(Alnus)* Predominent Vegetation
    - 327.4 - Mixed Shrub *(Prunus/Symphoricarpos/Crataegus)*
    - 327.9 - Undifferentiated Shrub-Types
  - 328 - Microphyllous dwarf shrub
    - 328.1 - Spruce-Fir *(Picea-Abies)* Krummholz Types
    - 328.2 - Mountain Heath Types *(Vaccinium/Cassiope/Phyllodoce)*
    - 328.3 - Mountain Avens Types *(Dryas)*
    - 328.4 - Juniper *(Juniperus)*-Bearberry *(Arctostaphylos)* Types
    - 328.9 - Undifferentiated
  - 329 - Undifferentiated complexes of shrub/scrub types
- 330 - Savanna-like Types
  - 331 - Tall shrub/scrub over herb layer
  - 332 - Broad-leaved tree over herb layer
  - 333 - Coniferous tree over herb layer
  - 334 - Mixed tree over herb layer
  - 335 - Broad-leaved tree over low shrub layer

PRIMARY CLASSES

SECONDARY CLASSES

TERTIARY CLASSES

QUATERNARY CLASSES

- 336 - Coniferous tree over low shrub layer
- 337 - Mixed tree over low shrub layer
- 339 - Undifferentiated complexes of savanna-like types
- 340 - Forest and Woodland Types
  - 341 - Conifer forests
    - 341.1 - Pine *(Pinus)* Prominent Vegetation
    - 341.2 - Douglas Fir *(Pseudotsuga)* Prominent
    - 341.3 - Pine/Spruce *(Pinus/Picea)*
    - 341.4 - Spruce *(Picea)* Prominent
    - 341.5 - Spruce/Fir *(Picea/Abies)*
    - 341.6 - Fir/Larch *(Abies/Larix)*
    - 341.9 - Undifferentiated
  - 342 - Broadleaf Forests
    - 342.1 - Poplar *(Populus)*Prominent Vegetation
    - 342.2 - Birch *(Betula)* Prominent Vegetation
  - 343 - Conifer-broadleaf mixed forests and woodlands
    - 343.1 - Pine/Poplar *(Pinus/Populus)*
    - 343.2 - Spruce/Poplar *(Picea/Populus)*
    - 343.3 - Douglas Fir/Poplar *(Pseudotsuga/Populus)*
  - 344 - Broadleaf-conifer mixed forests and woodlands
    - 344.1 - Poplar/Pine *(Populus/Pinus)*
    - 344.2 - Poplar/Spruce *(Populus/Picea)*
    - 344.2 - Poplar/Douglas Fir *(Populus/Pseudotsuga)*
  - 349 - Undifferentiated complexes of forest and woodland types
- 390 - Undifferentiated Natural Vegetation

400 - CULTURAL VEGETATION
- 410 - Cultural herbaceous types
  - 411-419 - Tertiary levels duplicate those of Natural Vegetation (300)
- 420 - Cultural shrub/scrub types
  - 421-429 - Tertiary levels duplicate those of Natural Vegetation (300)
- 430 - Cultural savanna-like types
  - 431-437, 439 - Tertiary levels duplicate those of Natural Vegetation
- 440 - Cultural forest and woodland types
  - 441-443, 449 - Tertiary levels duplicate those of Natural Vegetation
- 490 - Undifferentiated cultural vegetation types

500 - AGRICULTURAL PRODUCTION
- 510 - Field crops
- 520 - Vegetable and truck crops
- 530 - Tree, shrub, and vine crops

PRIMARY CLASSES

SECONDARY CLASSES

TERTIARY CLASSES

QUATERNARY CLASSES

540 - Pasture
550 - Horticultural specialties
560 - Non-producing fallow, transitional, or idle land
570 - Agricultural production facilities
580 - Aquaculture
590 - Undifferentiated agricultural production

600 - URBAN, INDUSTRIAL, AND TRANSPORTATION
610 - Residential
620 - Commercial and services
630 - Institutional
640 - Industrial
650 - Transportation, communications, and utilities
651 - Man and Material Transport
651.1 - Rail
651.2 - Motor Vehicle
651.3 - Water
651.4 - Air
651.5 - Trails, foot and animal
651.9 - Undifferentiated
652 - Utilities distribution
653 - Power production
654 - Communication
655 - Sewer and solid waste
659 - Undifferentiated
670 - Vacant plots and lots
690 - Undifferentiated urban

700 - EXTRACTIVE INDUSTRY AND NATURAL DISASTERS
710 - Non-Renewable Resource Extraction
711 - Sand and Gravel
712 - Rock quarrie
713 - Petroleum Extraction - Gas and oil fields
714 - Oil shale and sand extraction
715 - Coal/peat
716 - Non-metalic, chemical, fertilizer, etc.
717 - Metalic
719 - Undifferentiated
720 - Renewable resource extraction
721 - Forest harvest
721.1 - Clearcut Forest
721.2 - Selective Forest Cut
722 - Fisheries
729 - Undifferentiated

PRIMARY CLASSES

SECONDARY CLASSES

TERTIARY CLASSES

QUATERNARY CLASSES

730 - Natural disasters
- 731 - Earth
- 732 - Air
- 733 - Fire
- 734 - Water
- 735 - Disease
- 739 - Undifferentiated

800 - RECREATION AND OPEN SPACE RELATED
- 810 - Natural greenways, open space and buffer zones
- 820 - Preservation areas and natural museums
- 830 - Improved and developed open space
- 840 - Historical and archeological sites
- 850 - Scenic views
- 860 - Rock hounding, paleontological sites
- 870 - Recreation facilities
- 880 - Designated destructive use areas
- 890 - Undifferentiated

900 - OBSCURED LAND
- 910 - Clouds and fog
- 920 - Smoke and haze
- 930 - Dust and sand storms
- 940 - Smog
- 990 - Undifferentiated obscured land

Service of the U S Department of Agriculture and supplemented from other sources. These statistics, which are available only for States, are provided by the various government agencies which compile information on some categories of land use, several of which parallel the U.S G.S. land use classification system

TABLE 1 —*Major uses of land, United States, 1969* [1]

	Acres (millions)	Hectares (millions)	Percent
Cropland	472	191	20 9
Cropland used for crops	333	135	---
Cropland harvested	286	116	---
Crop failure	6	2	---
Cultivated summer fallow	41	17	---
Soil improvement crops and idle cropland	51	21	---
Cropland used only for pasture	88	35	---
Grassland pasture and range [2]	604	245	26 7
Forest land	723	293	31 9
Grazed	198	80	---
Not grazed	525	213	---
Special uses [3]	178	72	7 9
Urban areas	35	14	---
Transportation areas	26	11	---
Rural parks	49	19	---
Wildlife refuges	32	13	---
National defense flood control, and industrial areas	26	11	---
State-owned institutions and miscellaneous other uses	2	1	---
Farmsteads, farm roads, and lanes	8	3	---
Miscellaneous land [4]	287	116	12 6

[1] Frey, H T 1973 Does not include area covered by water in streams more than ⅛ of a mile in width and lakes, reservoirs, and so forth of more than 40 acres in size.
[2] Includes pasture that is to be included with cropland in the U S G S classification system
[3] Except for urban and built-up areas and transportation uses these special uses will be classified by dominant cover under the U S G S classification system
[4] Tundra, glaciers and icefields marshes open swamps bare rock areas, deserts beaches and other miscellaneous land.

The land use and land cover classification system presented in this report (table 2) includes only the more generalized first and second levels The system satisfies the three major attributes of the classification process as outlined by Grigg (1965) · (1) it gives names to categories by simply using accepted terminology; (2) it enables information to be transmitted, and (3) it allows inductive generalizations to be made The classification system is capable of further refinement on the basis of more extended and varied use At the more generalized levels it should meet the principal objective of providing a land use and land cover classification system for use in land use planning and management activities Attainment of the more fundamental and long-range objective of providing a standardized system of land use and land cover classification for national and regional studies will depend on the improvement that should result from widespread use of the system.

TABLE 2 —*Land use and land cover classification system for use with remote sensor data*

Level I	Level II
1 Urban or Built-up Land	11 Residential
	12 Commercial and Services.
	13 Industrial
	14 Transportation, Communications, and Utilities
	15 Industrial and Commercial Complexes
	16 Mixed Urban or Built-up Land
	17 Other Urban or Built-up Land.
2 Agricultural Land	21 Cropland and Pasture.
	22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
	23 Confined Feeding Operations
	24 Other Agricultural Land
3 Rangeland	31 Herbaceous Rangeland
	32 Shrub and Brush Rangeland
	33 Mixed Rangeland.
4 Forest Land	41 Deciduous Forest Land
	42 Evergreen Forest Land
	43 Mixed Forest Land
5 Water	51 Streams and Canals
	52 Lakes
	53 Reservoirs
	54 Bays and Estuaries
6 Wetland	61 Forested Wetland.
	62 Nonforested Wetland
7 Barren Land	71 Dry Salt Flats
	72 Beaches
	73 Sandy Areas other than Beaches.
	74 Bare Exposed Rock.
	75 Strip Mines Quarries, and Gravel Pits
	76 Transitional Areas
	77 Mixed Barren Land
8 Tundra	81 Shrub and Brush Tundra
	82 Herbaceous Tundra
	83 Bare Ground Tundra
	84 Wet Tundra.
	85 Mixed Tundra
9 Perennial Snow or Ice	91 Perennial Snowfields
	92 Glaciers

As further advances in technology are made, it may be necessary to modify the classification system for use with automatic data analysis The LANDSAT and Skylab missions and the high-altitude aircraft program of the National Aeronautics and Space Administration have offered opportunities for nationwide testing of the feasibility of using this classification system to obtain land use information on a uniform basis

The approach to land use and land cover classification embodied in the system described herein is "resource oriented," in contrast, for example, with the "people orientation" of the "Standard Land Use

LLG 3

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Numerical Analysis of Multispectral Data

Master Outline Category: 7.2

Category & Module Title: Numerical Analysis of Multispectral Data--Basic Theory and Concepts

Goal and Objectives:

The goal of this module is to provide trainees with a minimal but adequate understanding of multispectral scanner data and basic methods of analysis and classification at a generic or general level as a background to more in-depth training in system-specific computer methods.

Specific objectives are: (1) to provide an understanding of what multispectral signatures are and how they can be identified by pattern recognition techniques; (2) how supervised and unsupervised classification is done; and (3) what some of the alternative approaches to numerical classification of the MSS signatures are.

Rationale and Summary:

It is thought that if an image analyst sufficiently understands the above indicated material in a general sense, he can--as a ground truth and information expert--both adequately perform his role in interactive computer analysis and also more easily comprehend and learn the specific analytical techniques used at the various image analysis installations with which he may work.

Some natural resource professionals who can work with a computer technician or scientist may need to know little more than what is embodied in the full and expanded content of this training module to be effective as a part of the image analysis team.

This module merely covers the background for the more specific knowledge and skill to be presented in the following elements of the short course and in recommended collateral study.

Prerequisite Knowledge:

Some prior knowledge of physics--more specifically of the electromagnetic spectrum--and of statistics is assumed.

Elements Covered:

1. Review of nature of LANDSAT MSS data, of some typical multispectral signatures, and demonstration of what the MSS data to be analyzed and classified look like.

2. The concept and method of classification in multidimensional space--Pattern Recognition.

3. Supervised and unsupervised classification.

4. Spectral classes vs. information classes.

5. The role and use of ground knowledge and corollary data in classification and vericiation.

6. The role of visually stratified and interpreted LANDSAT imagery in digital data analysis, classification and verification.

7. The nature of computed results and output products.

References & Recommended Reading:

Sabins. Remote Sensing Principles and Interpretation. Freeman. Pp. 235-253, 258-274.

Manual of Remote Sensing, Vol. 1. Pp. 689; 747-785.

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Screening and Ordering LANDSAT
Information Sources, Roles of Various
Groups in Advise and Assistance

These two topics are reasonably well covered by Kroeck, Everybody's Space Handbook, Chapters 4, 5 and 6.

Trainees are urged to read these chapters and ask appropriate questions of clarification in the last discussion session. If time permits, an instructor may make some remarks of amplication on these topics.

TRAINING FOR MONTANA DEMONSTRATION PROJECTS

Comprehensive Laboratory and Field Exercise

Master Outline Category:

10.1, 11.2 and 9.21

Master Module Title:

Visual Interpretation; Multistage Methodologies; and Selection of Training Sites

Title of Exercise:

Visual interpretation of LANDSAT images, highflight and conventional aerial photography and their interactive use with computer analysis of the LANDSAT data.

Goals:

(1) Achieve familiarization and initial experience with visual interpretation of LANDSAT images and learn where and how this kind of interpretation and analysis should be done interactively with computer analysis of digital data.

(2) Achieve an appreciation of the kinds and levels of information that can be visually derived from state-of-the-art LANDSAT images as compared to highflight and conventional aerial photography.

(3) Demonstrate how these three kinds of images can be used interactively in a multistage sampling mode to increase the efficiency of acquisition of data and information about earth resources.

(4) Develop an improved understanding of mapping and information legend requirements and limitations when working with LANDSAT images or data.

Introduction to Problem

All necessary introduction and background for this problem will have been provided in previous lecture/discussions. Familiarization with the three kinds of images to be used will have been attained through a laboratory and field familiarization exercise on the first and second days of the training course.

Introduction to Problem (Continued)

Carefully read the goals of this exercise and keep them clearly in mind as you progress through the individual tasks and experiences.

The training staff will be available to answer questions and make suggestions throughout the exercise. Start with the first procedural step and work systematically through the recommended activities. It is suggested that you write out or tabularize an information set in response to each question. These are intended to reinforce key points. A concrete response helps fix items in your mind and reinforce the learning process.

On the morning of the last day the group will field check the results of this exercise and clear up any remaining questions.

With this experience it is expected that those who come to NASA-Ames Research Center for the second week of training and workshop will be able "to take off running" in the procedures for digital data analysis.

Equipment and Materials Furnished:

2	LANDSAT, full frame CIR specially enhanced 1:250,000	For demonstration and shared use only
2	LANDSAT, full frame B&W, Bands 5 & 7, 1:250,000	
1	1:250,000 mylar culture overlay	
10	Random dot acreage grids	

1 Short course notebook

1 LANDSAT, 1/4-frame CIR specially enhanced, 1 250,000

4 Frames, Highflight CIR transparencies @ 1·130,000

4 Stereo-models, B&W, 1.20,000

4 Sheets mylar, 10" x 10"

2 Mylar overlay for 1/4-frame @ 1.250,000, 15" x 15"

2 Reference books (Rudd & Kroeck)

Trainee-Furnished Items.

1 Low power magnifier; 3-6x (10x only if large field of view)

1 Engineer's scale; inches & 1/10th, 1/50th/or metric in mm's

1 Rapidograph pens with black, red and blue ink, or grease pencils in same colors

1 Pocket calculator, convenient and optional

1 Packed (field) stereoscope, optional

1 Acreage dot grid or 1/10th-inch squares in 2 x 2-inch/4 x 4-inch square, optional

Trainee-Furnished Items (Continued):

1 Compass, optional (Sylva, hikers type or better)

1 Camera, optional

Procedures and Specific Instructions:

(1) By one edge fasten a large sheet of mylar to the 1:250,000, 1/4-frame of specially enhanced LANDSAT imagery. Mark positioning reference points on the overlay.

(2) With an acetate marking pen, locate the corners of each alternate highflight frame on this overlay and mark with a dashed line the exterior boundary of the area of common coverage.

(3) Within this area, similarly mark the areas covered by the 1:20,000 aerial photography which you were provided. Use solid lines to define these areas.

(4) In a simple list, tabulate what you learned about the comparative resolution, interpretable detail and optimum kinds of uses of each of the three kinds of images and scales provided.

Q. What is the smallest thing you can identify at each of the three scales within the areas defined in (3)?

Q List the changes over time that you can observe by comparison of the three kinds and dates of imagery within the areas defined in (3).

(5) Delineate the entire 1/4-frame area of the 1:250,000 LANDSAT scene at primary legend level, defining all free water surfaces in blue and all other delineation boundaries in red. Identify and label each delineation according to each of the two legend systems provided. In some cases this might require adding a line to delineate differences between the two legend systems but in both cases each delineation should carry both appropriate numerical designators. For contrasting types with substantial significance in land-use planning or resource management, you should map down to 1/2-inch^2 or 1 cm^2 and in some cases may wish to identify and locate smaller point data; e g., small reservoirs, towns, eroded or excavated areas.

(6) Within the area marked by a dashed line, Step (2), similarly delineate, identify and label the LANDSAT images at secondary level according to both legend systems. Use the same color scheme of inks (or wax pencil) for the mapping.

Q. For what kinds of uses would the map produced in Step (5) and in Step (6) be useful?

Procedures and Specific Instructions (Continued)

Q. From Step (6) could you have delineated and identified any of the features from LANDSAT at a tertiary or quaternary level? If so, cite specific examples and explain.

(7) We assume that each of you represents a department from which a demonstration project has been proposed. In some cases, the preliminary plan submitted to NASA-ARC suggested a legend. With respect to your demonstration project, respond to the following questions:

Q. What kinds of essential information can you derive from visual interpretation of LANDSAT at 1:250,000; from ca. 1·130,000 highflight; from conventional scale 1·20,000 B&W aerial photography, from ground observation/measurement in a multistage mode? List and discuss as appropriate.

Q. Can you derive any of the above information, or additional kinds, from B&W LANDSAT, Band 5 or Band 7, 1:250,000 scale, better than from CIR at 1:250,000? List and explain why.

Q. If your group has already proposed a legend, how well will it work with LANDSAT, highflight and with conventional 1:20,000 aerial photography? Discuss and suggest solutions where the legend or level of informational detail doesn't seem to fit the characteristics and information content of LANDSAT.

(8) Within the solid lines marking the four stereo models of 1.20,000 photography, prepare a tabulation on the form provided (Table 1) of the additional LANDSAT image types that could be delineated if the scale were large enough, describe each image and make a tentative identification of each, first without looking at the support photography, then by looking at the 1.20,000 photography monocularly and in stereo.

Q. What image types were correctly identified without looking at the 1.20,000 photography?

Q. What additional images were correctly identified from the 1 20,000 photography?

Q. What subjects of importance to you were identifiable on the 1·20,000 that could not be seen on the LANDSAT image? List. Could these be seen and identified on the highflight 1.130,000 CIR photography?

Q How would you propose obtaining information on those things not discernable on either the LANDSAT or highflight? In doing this, would an analysis of either of the 1 250,000 or 1.130,000 images be helpful? How?

Procedures and Specific Instructions (Continued)

(9) Select one stereo model of highflight that is of greatest interest to you that also includes one of the 1:20,000 stereo models and map each to an intensity of 1/2-in.^{2} or 1 cm.^{2} for contrasting important types, label each delineation to a tertiary legend level of your own design based on either the OSU or USGS legends (whichever you prefer). Prepare an organized list of delineations you cannot identify for subsequent field checking.

(10) Tape a second mylar overlay on the LANDSAT 1/4-frame scene by taping on a different edge so both the original and new overlays can be superimposed or used individually. Mark control or location marks on the new overlay.

(11) On the new overlay mark a rectangular window by using the following diagonal coordinates for the window. Use the upper left-hand corner of the scene as 0.0.

X = ; Y =

X = ; Y =

This simulates one of the same procedures used in computer selection of a window or a training area.

(12) Within this window, tabulate all of the kinds of information classes in which you would be interested if you were concerned about both land-use planning and renewable resource management within this window For each information class, tabulate the kinds of spectral signatures that you judge to make it up. Describe these spectral signatures as to color and form (shape, if appropriate). Indicate on the tabulation whether or not the information class is HHo, highly homogeneous throughout the window as regards spectral variability; MHo, moderately homogeneous, MHe, moderately heterogeneous; or HHe, highly heterogeneous as to spectral variability.

(13) Make a matrix table of information classes and for each comparison among classes indicate the relative likelihood of confusion or error in spectral classification between each of the pairs of information classes by entering the following symbols in the appropriate block of the matrix table·

0 = No confusion

+ = Some confusion possible

++ = High possibility of confusion

+++ = Extreme or very high likelihood of confusion

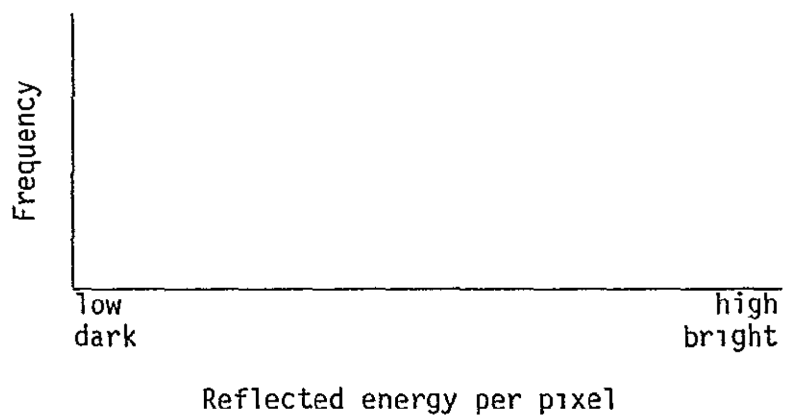
Procedures and Specific Instructions (Continued)

Information Class	A	B	C	D	E	F	G
A	0						
B	0	0					
C	+	+	0				
D	-	++	+	0			
E	++	0	0	0	0		
F	+++	++	0	+	+++	0	
G	+	0	++	0	0	+	0

Q. Can you see a way to minimize this confusion and possible error in classification by pre-stratification of the window and then classifying within these strata? If so, map the strata on the second overlay.

Q. If you cannot eliminate the possibility of confusion and error by stratification prior to analysis, can you see any other way to deal with the problem?

(14) Select one information class from Step (13) that has only a "+" or lower likelihood of confusion and one that has mostly "++" or "+++" likelihood. Examine areas representing these subjects on the 1:250,000 Black & White Band 5 and Band 7 images and indicate in tabular or narrative and graphic form what you think the frequency distribution of energy values would look like within a training set representing each of these two information classes.



APPENDIX X

Documentation: Consultant's Final Report - "A Technical Evaluation of the Northern California Remote Sensing and Technology Transfer Project, NASA Grant 2244," by Dr. Lawrence Fox III

CONSULTANT'S FINAL REPORT

A TECHNICAL EVALUATION OF THE NORTHERN CALIFORNIA REMOTE SENSING AND TECHNOLOGY TRANSFER PROJECT

NASA GRANT #2244

By

Dr. Lawrence Fox, III
Professor of Forestry
Humboldt State University

June, 1978

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CONTENTS

PURPOSE

This report has been prepared to aid in the overall evaluation of NASA's effort to transfer remote sensing technology to Humboldt State University and the people of northern California. The aim is to provide an objective, independent evaluation of the technical aspects of this project.

BACKGROUND AND RATIONALE

The author is thoroughly familiar with the theory and practice of modern remote sensing, having recently (1976) completed a Masters and Ph.D. program in Remote Sensing and Natural Resources Management at the University of Michigan. As a current member of the Forestry Department faculty at Humboldt State University, the author is also in a good position to evaluate the technology transfer effort to academic programs at Humboldt State.

A major concern is for the independence and objectivity of this report. The author was employed by this grant from June 15, 1977 until September 15, 1977 as a Technical Coordinator. His function was to address the technical needs of the project during this time. It is the author's opinion that this working association with the project does not constitute a conflict of interest. The author was not involved in obtaining the original grant from NASA and did not have a part in writing the original proposal for the grant. Of course, the author does hold a tenure track position with Humboldt State University and will naturally strive for the best possible situation for that University.

This is the second and final report on the technical effectiveness of this project. The first report covered the period from September 15 to December 31, 1977. This report covers the grant activities until June 15, 1978. The various conclusions of the first report will be referenced in this document and comparative evaluations will be made. The grant efforts have been cooperative between the staff at NASA Ames and at Humboldt State. The activities have therefore been reviewed under two major headings: Humboldt State Project, and NASA Ames. The effort at Ames has been further broken down into assistance and training. Recommendations follow these separate evaluations.

HUMBOLDT STATE PROJECT

INITIAL PRESENTATIONS:

The major NASA Western Regional Applications presentation was made to a multi-county meeting of Boards of Supervisors in Santa Rosa, California. It was recommended in the previous report that presentations be made at a simpler level than previously and that more patience be used to re-explain how the technology works. These two recommendations were followed. However, communication problems were still encountered at the Santa Rosa presentations. The audience seemed stunned by the technology even when presented at a simple level. Perhaps the failure was in not working closely enough with county people's needs and talking about how Remote Sensing could address those needs. Possibly, examples could be added from other county remote sensing projects to strengthen the presentation. The answer to this problem is not yet readily apparent and needs considerably more thought and planning for future presentations. Perhaps the Landsat system is simply not attractive to county government because of their requirements for excellent resolution and a limited geographical area of jurisdiction.

PLANNING DEMONSTRATION PROJECTS:

In the previous report, it was stated that "...the northern California (Humboldt State) team of full time employees has an acute lack of understanding about computer processing. Because of this, it is very difficult to define problems and lay on the proper time restraints." This condition has not changed significantly during the past six months. The condition continues to contribute to the lag in project starts in northern California. NASA Ames personnel have not become involved in the review of initial project planning, comments to follow in the "NASA Ames Assistance" section of this report. The Humboldt State staff have failed to develop technical plans with potential cooperators. This statement reflects on the performance of the consultant (the author). Part of my function was to develop these plans. My time commitment of one day per week was not enough to carry out this planning process effectively. Partly because of this problem, several projects are in limbo in northern California now.

COMPLETING DEMONSTRATION PROJECTS·

The only project currently underway is the U.S. Fish and Wildlife Service Project, "Vegetation Mapping on the Hoopa Square Indian Reservation." There has been no one technically trained to deal with the complexity of this project, employed full time, on the Humboldt State staff during the period of time this report covers. The production schedule has fallen behind because of this. The U.S. Fish and Wildlife Service employee has been floundering, receiving little technical assistance from the Humboldt State personnel. The author has provided consulting service in this area directly to the U.S. Fish and Wildlife Service employee. The author's minimum time commitment and unfamiliarity with the precise workings of the EDITOR computer system have contributed to this problem.

The Humboldt State staff will continue to experience difficulty in completing this project unless their technical needs are addressed. Some relief is likely to be felt, however, since the U.S. Fish and Wildlife Service employee is becoming competent enough technically to carry out his responsibilities independently. It is also anticipated that the author will be employed full time during the summer of 1978.

NASA AMES ASSISTANCE

In my previous report, the needs of the U.S. Fish and Wildlife Service employee (Ken Mayer) were outlined. Assistance from NASA Ames personnel was sporadic during the fall of 1977. Many factors probably contributed to this: geographic separation, other commitments of NASA personnel, historical precedent (NASA has never really "trained" the people they awarded grants to in the past). This condition was partially rectified during the period covered by this report with two major accomplishments:

1) A technical manager (Dave Peterson) was assigned to the U.S. Fish and Wildlife Service project. Dave was invaluable in defining the project. A production schedule was devised.
2) A new resource was found within NASA for guidance in digital processing using the EDITOR Software Package. Len Gaydos, from the USGS Geography Program, Landsat group, met with all concerned and began to address Humboldt State's technical problems.

The two points above indicate significant improvement in the area of technical assistance. The importance of Len Gaydos and his staff (especially Bill Newland) can't be overemphasized. The USGS people can assist the Humboldt State staff in completing the U.S. Fish and Wildlife Service Project on schedule. Dave Peterson has best input to project definition and technical planning. With continued sharing of responsibilities between the USGS and NASA Ames, it seems that technical assistance would be adequate for future demonstration projects at Humboldt State.

The ineffectiveness of the remote computer terminal at Humboldt State was also addressed in the previous report. The NASA personnel seem to expect Humboldt State personnel to learn by doing on the remote terminal. I understand that this philosophy was probably dictated by the circumstances more than anything else. No formalized instruction is available for EDITOR. It seems to me the "learn by doing" process is a very effective one when used by people actually working at NASA Ames. Because of Humboldt's remote location, the idea didn't seem to work too well. The assistance from the USGS people in statistical analysis, using EDITOR, has already made the terminal more useful for personnel at Humboldt State.

NASA AMES TRAINING:

In the previous report, it was stated that "...there has been no support from Robin Welch and company for any of the projects or plans for projects in Arcata." This situation is largely unchanged except for the response from Charles Poulton. Poulton has taken an interest in the work and has provided valuable assistance in overall planning and philosophical approach. However, Poulton does not feel he can provide the technical assistance needed in northern California because he is not familiar with digital analysis of Landsat data. In fact, the effective path through the variety of computer classification systems at Ames is so complicated that Poulton has requested the staff at Humboldt State to provide him complete documentation on Landsat digital data analysis.

RECOMMENDATIONS

Several projects have stalled in the planning stage in northern California. Immediate action should be taken if these projects are to have a chance of being activated.

1) A technically competent Landsat data analyst and photo interpreter should be transferred to the northern California project immediately. He/she must reside in Arcata and work full time on the project for one year.

   This person would spend about one-third of his/her time planning demonstration projects with potential NASA cooperators. The remainder would be spent lecturing in the remote sensing course at Humboldt State University, training selected Humboldt State faculty, improving Humboldt State computer capability and training the northern California project staff.

   This arrangement would meet two pressing needs:

   a) to deal technically with potential cooperators for Landsat demonstration projects, and

   b) to transfer confidence to Humboldt State professors and administrators. This to aid in transferring the remote sensing education process to Humboldt State and developing technical skills at Humboldt State to meet the needs of potential NASA cooperators in northern California.

2) A formal cooperative arrangement should be made with USGS at Ames. USGS to provide detailed technical assistance in computer processing to the Humboldt State project. NASA personnel to continue to be involved in initial project planning and generation of output products.

3) Formal training programs in digital analysis of Landsat data should be initiated by NASA Ames for the Humboldt State project personnel. This will make the entire project more technical in the eyes of potential cooperators and make Humboldt State personnel able to effectively supervise on-going demonstration projects.

4) NASA should provide complete documentation on remote sensing projects completed elsewhere. This "evidence" should help the Humboldt State project staff attract potential cooperators.

APPENDIX VIII

Documentation: Description of WRAP Program in Earliest Stages, WRAP Overall Plans, WRAP Information Sheet, CORSE 1978

NOTE: All WRAP activities have now been spun off into private sector contracts.

Example: "Signature" newsletter now "Plain Brown Wrapper," Clear Air, Inc. (Phoebe Williams, et. al.)

Training function: now being done by Air View Specialists, Inc. (Robin Welch, Charles Poulton, et. al.)

PROPOSED PLAN

WESTERN REGIONAL APPLICATIONS PROGRAM

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Ames Research Center

October 1977

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A PLAN FOR THE

WESTERN REGIONAL APPLICATIONS PROGRAM

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A PLAN FOR THE

WESTERN REGION APPLICATIONS PROGRAM

I. EXECUTIVE OVERVIEW

1.0 BASIC PREMISES

In establishing the National Aeronautics and Space Agency in the National Aeronautics and Space Act of 1958, (72 STAT. 426;42-U.S.G. 2451 SEQ) as amended, a charter was given which included the mission

> "to provide for the widest practicable and appropriate dissemination of information concerning NASA's activities and results".

It is in compliance with and performance of that mandate from the President and Congress that a program to accomplish technology transfer is being planned and implemented. However, had the original charter not included such foresight and wisdom, common sense, the demands of knowledgable users, the pressing needs of today, and national priorities would have forced the creation of an institutionalized mechanism for technology transfer. Indeed, these are the drivers for its current implementation.

There is much discussion among politicians, scientists, scholars, and industrialists as to whether technology transfer can be accomplished and if so, how. The viability and credibility of the transfer of government-sponsored technology has already been established by the Japanese. Their computer industry is a prime example, and its impact is being felt around the world today, including the United States.

One of the central elements of the Japanese technology transfer was a synergism that would not, probably could not, have been realized outside of government sponsorship. Yet a free enterprise system was not endangered. This plan assumes an equivalent capability within the United States and strives for meaningful accomplishments. Its synergism will be derived from full and active participation by NASA, academia, industrial suppliers, and users from the federal, state, and local and private sectors. Its success is dependant upon this participation. No single element can accomplish bringing about full utilization of NASA developed technology by itself. Any missing element will disproportionately diminish the value of the effort.

1.1 UNDERLYING PHILOSOPHY

There is a quotation which states, "Give a man a fish and he will have a meal. Assist him in learning to fish and he will have many meals". The underlying principle of this quotation reflects the basic philosophical approach to technology transfer that will be taken by the Western Region Applications Program in serving the 14 states depicted in Figure 1 in the most simplistic terms. The user is key and it is he who must apply the tools for lasting value to be achieved.

If technology transfer is only a tool to assist in the solution of problems, as indeed it is, then the funadmental fact that only the user can transfer technology must be recognized. Only the user can apply it to the fulfillment of requirements or achievement of goals. The complexity of the problem is thus reduced basically to a people relationship. The fundamental approach proposed by this plan in structuring that relationship is as follows:

> A user driven/user participatory cooperative arrangement involving <u>all</u> segments of society in the evaluation, demonstration, utilization, and development of technology in the solution of existing problems.

Technology transfer is an evolving process, with specific functions, as shown in Figure 2. Failure to identify each key function and its relationship to the overall structure could ultimately result in failure of the total process. Thus, this plan attempts to effectively mobilize and cooperatively integrate the talents, capabilities and resources of users, federal agencies, universities and industry in the accomplishment of the objectives of each function. This plan will discuss each function, its objectives, approaches, participation, resources, relationships to the whole and framework for accomplishment.

Since there presently exists no institutional mechanism for effectively transferring technology and no panacea on which to rely, new techniques must be developed concurrently with the transfer process. Some of the approaches identified in the plan may not prove feasible and thus will be revised, replaced or eliminated. In order that this can be accomplished without jeopardizing the transfer process, considerable flexibility must be afforded the performing organization.

To state the need for flexibility in another way, to be successful in technology transfer, there must be the opportunity for failures as well as successes in the evolutionary process. On-going accomplishments will be the measure of the successess. Future attainments will be the results of the knowledge and experience gained in failing attempts. This plan will have sufficient flexibility to accommodate both immediate and future successess. The key is the development of a cooperative relationship with the user community and not the transfer of a specific technology. For even in the failures in transferring one technology there will be success if a user relationship based on credibility is established. This relationship will provide a pipeline that will offer an immeasureable advantage in cost-effectiveness in future technology

WESTERN REGION

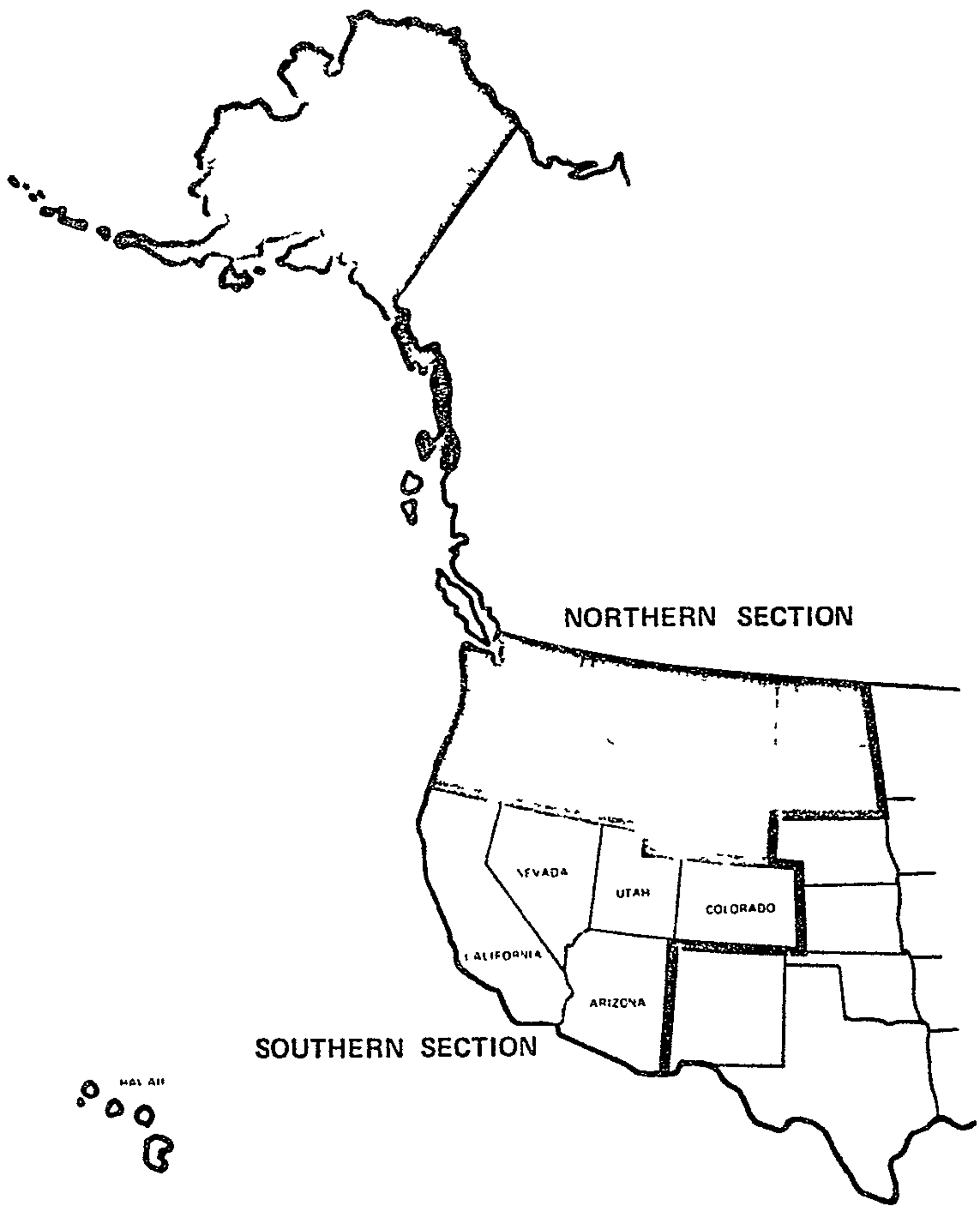

FIGURE 1

NAME ________________________________ NO. ________

TECHNOLOGY APPLICATION CURVE

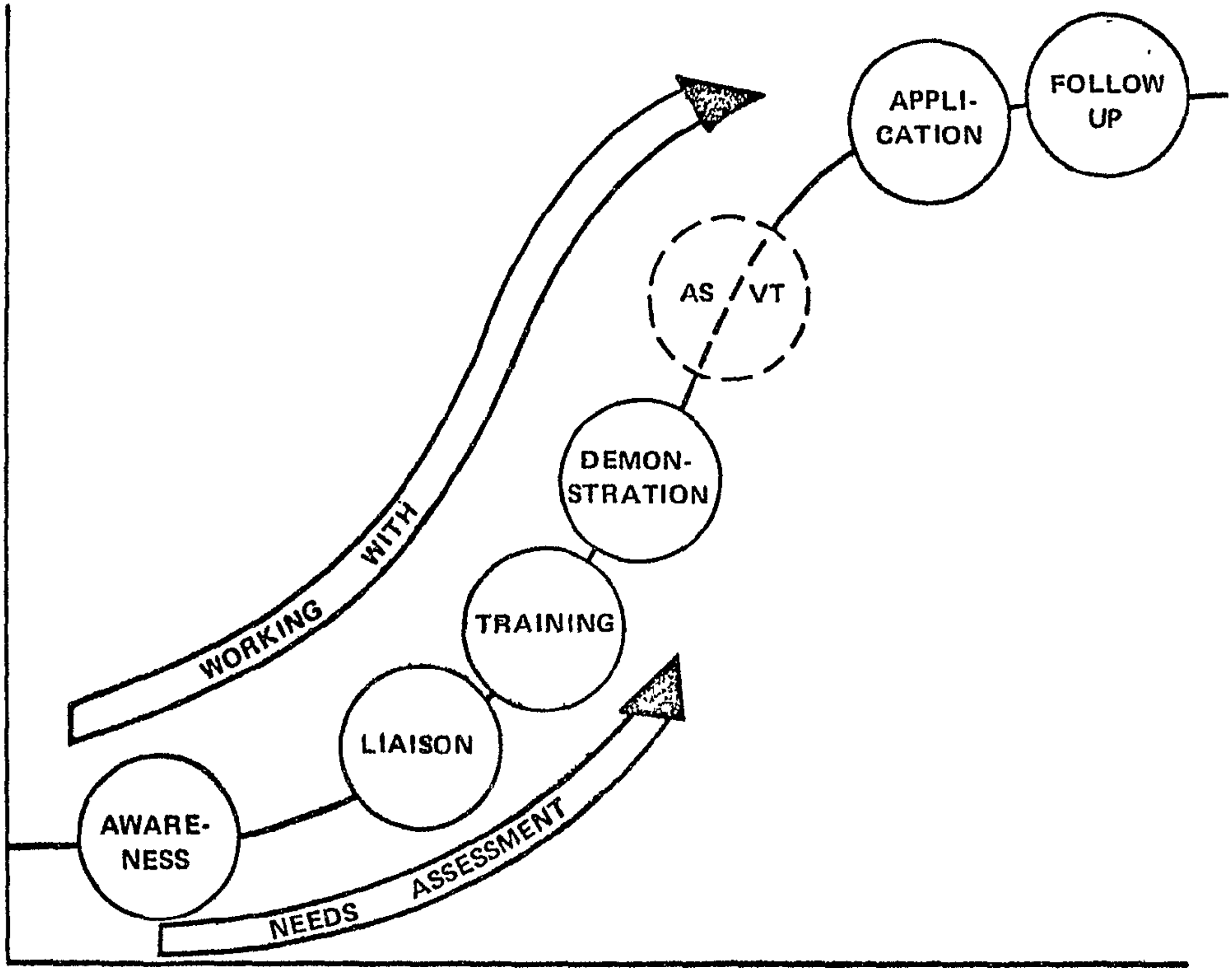

FIGURE 2

transfer efforts. Thus, through integrity in all approaches, there may be failures in transfer, but there will be no overall losses.

2.0 A BROAD VIEW OF THE PLAN

Technology transfer can be viewed as having three identifiable phases. Each is distinguished by the characteristics of the user community:

The First Phase (Phase I)

- a large, largely unfulfilled, and sometimes unrecognized, demand for the output of a given technology by the user community. While technology transfer itself must always be user-driven, there is an initial phase in its implementation that the technology determines the process. During this phase providing a clear understanding of the technology itself is the dominate concern. Thus, this phase is essentially technology driven.

The Second Phase (Phase II)

- the stage during which fulfillment and demand co-exist, and, in fact, in which the proportion and variety of users is sufficient to accomplish a significant portion of the transfer function through referencing, user-implemented information exchange, media reporting, and simply word of mouth. The technology is well on its way to becoming "a household word". The main concern of technology transfer will be working with the users by supporting their transfer efforts, by assisting in assuring the transfer of fact and elimination of fiction. Transfer efforts of the program and the user will co-exist.

The Final Phase (Phase III)

- that phase when existing technology has been sufficiently explored and exploited that users are able to identify on-going needs and provide the feedback which should, and hopefully will, give new direction to technology. Just as technology transfer is a dynamic process, so must the technology itself be dynamic. The use of technology has always led to new directions and on-going refinements. So must be done here. The emphasis in the technology transfer process is now verification and feedback as the technology becomes user-directed.

In order to accommodate the unique requirements of each phase, the Western Region Applications Program will have a modular and extremely flexible structure. It will also have the capacity to assist users in varying phases of the process as well as handle varying technologies in different phases simultaneously. These technologies could be represented by Landsat 1 and 2 in Phase III with Landsat C in Phase II and Landsat D in Phase I, or Seasat in Phase I and one of the Landsats in Phase II.

Simultaneously, the components of each function within the technology transfer process will have sufficient impermanence to be readily modified or eliminated as industry and academia assume those prudent risks from which their profits and growth and the nation's economic well-being and technological leadership are maintained. In fact, one of the surest measures of success in technology transfer will be the assumption by industry and academia of their designated roles. Such role assumption can only be achieved through making technology transfer a synergistic and cooperative venture in every facet of the process. The crucial element will be direct interface between users, industrial suppliers, and academia with the NASA-developed technology the point of common interest. This will be encouraged by external participation in each function within the Western Region Applications Program organization in each phase of technology transfer.

Although each phase will be described in detail, there are elements that are common to all. These elements the same as and will interrelate in the same manner as those in the technology transfer process itself; that is, awareness, liaison, training demonstration and application, as the Western Region Applications Program works with and within the 14 states. Some points are common to all phases and will be amplified here.

The program has been structured with a single, clearly identifiable, interface for each function. This is essential for two reasons:

(1) those external to NASA must have a focal point for concerns and information of a given type,

(2) that single focal point will be able to provide perspectives on the area of concern that cannot be achieved through diffused and segmented responsibility.

Each functional area of the organization (Figure 3) will interface with all sectors - federal, state and local governmental, academic, and private. (A chart graphically depicting the relationships proposed throughout this plan is included as part of the summary. It is through this broad interface that the synergism and benefits of varying and interlocking ideas competing in an open arena will be gained.

The inclusion of all levels of government in "outreach" programs is a generally accepted concept. This acceptance is extended by many to include academia. That the private sector should be treated by such programs with parity is a less accepted principle. Yet this sector's full and equal participation is essential to technology transfer because of its capacity for independent action and the multiplying effects of its investments. The circumstances under which a governmental entity can match these capability are limited. In the private sector application of technology readily translates into new jobs and services. In the private sector risk capitol is truly available. But the risks must be reduced to prudent levels. It is in minimizing the risks that technology transfer can play a major role -

* firstly, through general education.
* secondly, by maintaining a body of reference information in terms of existing applications and techniques,
* thirdly, by providing a mechanism for feedback and new direction,
* and finally, by bringing together those offering services and equipment with those in need of such offerings.

WESTERN REGION APPLICATIONS PROGRAM

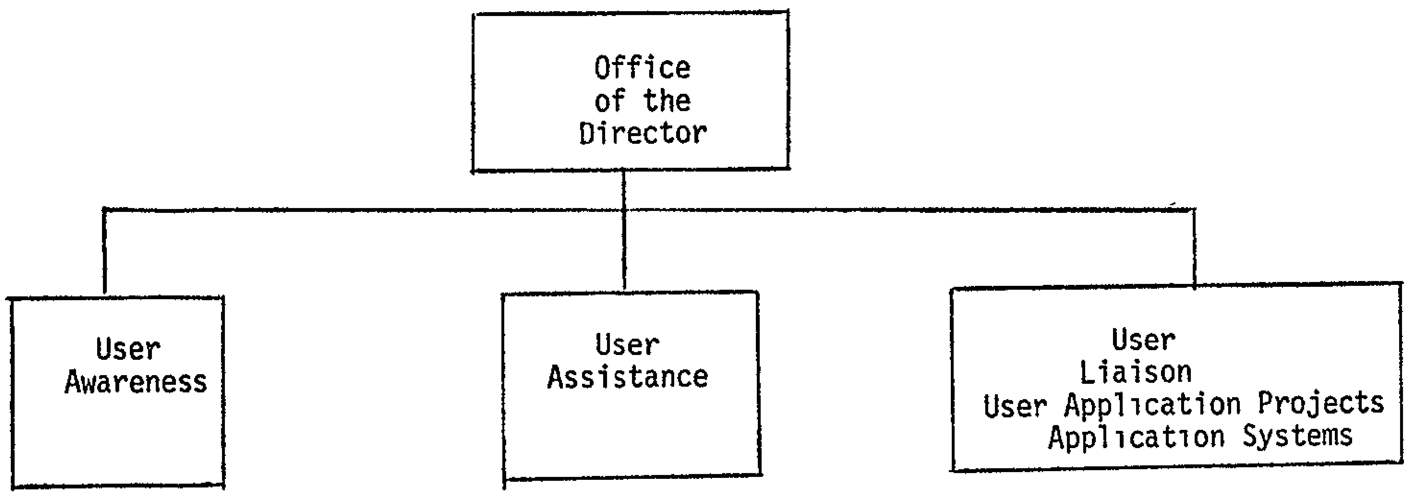

FIGURE 3

The Western Region Applications Program will do all these things. Thus, while the plan itself concentrates on regional, state and local governmental entities, private sector participation will be encouraged and accommodated in all functions.

It is extemely important to point out here that the objectives in staffing each function is to maintain a permanent nucleus of capability and obtain external participation wherever possible. This will result in a lean and efficient organization. There is no desire to build a technology transfer empire. This will be true within each function.

Incorporated into each major function of the plan is a reporting and analysis system which should assist greatly in the assessment of the technology itself, technology transfer and user commitment. These reporting systems might help to end circular discussions of the type presently surrounding Landsat as to whether the Federal government can commit to an operational system in the absence of prior commitments to operational use on the part of the user community, versus whether the user and producer communities can responsibly make the investments necessary for such commitments in the absence of Federal assurances to continuity as well as on-going development to meet currently unfulfilled and future needs. This is, of course, a problem of national magnitude.

There is another area that is national in its scope but has a direct bearing on the success of the regional programs. This is the problem of the need for information exchange on a nation-wide basis. The system and vehicles necessary to achieve this ideally belong in the hands of NASA Headquarters Office of Applications. They are identified here because they are a major dependency in the Western Region Applications Program. The first is the need for a comprehensive directory of available services and equipment, private and governmental in the case of services. The second is the need for an applications information system. It can be as simple as a regularly updated list of applications by type and sources of detailed information to something as sophisticated as an on-line data bank of key-words-in-context and application abstracts. An applications information source is essential to the success of the total program. The nation cannot afford for each region to independently operate within its myopic environment.

There are major issues involving the prerequisites of technology transfer that are not being addressed by this plan. Essentially these are the issues of policy and are beyond the scope and mission of the Western Region Applications Program Plan. They include, but are not limited to, such issues as a clear definition of roles, governmental and private, in the space and space derived data programs themselves, a definition of appropriate barriers between government responsibility and commercial opportunity, and a protection system for proprietory information and processes in a cooperative environment. Much of the success of this effort is dependent on the resolution of these issues, but that resolution must rest with policy makers at the highest level. Within the provinces of the Western Region Applications Program, mutually agreed upon procedures will be implemented in order to proceed in the absence of policy direction.

In summary, technology transfer as performed by the Western Region Applications Program will:

* provide an understanding of NASA-developed technology and its potential uses and benefits in meeting the operational needs of today's complex society-public and private,
* assist in the assessment of these technologies for specific applications and in the determination of future developments.

Its mission is not to fund, and not to implement, but to establish and propagate awareness and assist in demonstrations of the many uses and benefits of the space tools developed by NASA and of value here on Earth.

II. PHASE I - TECHNOLOGY DRIVEN

1.0 OVERVIEW

1.1 OBJECTIVES

As explained previously, in the initial phase of technology transfer the user environment is characterized by a large and largely unfulfilled requirement for the output of a given technology. Part of the lack of use is ignorance of its existence, part to lack of understanding of its uses, and part to human inertia or an unwillingness to pioneer. Therefore, the objective of Phase I must be a maximization of exposure to the technology and the uses to which it has been applied through every means available. This exposure is essential if the true value of the technology is to be established with minimal absorption of public funds and if a maximal return on past investments is to be realized through the benefits of use.

In order to accomplish this exposure, or awareness, all of man's sensory perceptions will be engaged - hearing, seeing, doing. Wherever an aggregate audience can be established within one of the 14 states, the word will go forth. The use of media will help to identify the existence of areas of interest, on-site presentations will help to establish the degree of such interest, the use of a mobile facility equipped with communications and demonstration equipment will help to establish the level of understanding, and all functions within the Western Region Applications Program will fulfill their design objectives of establishing the level of need and the degree of commitment.

The methodology for achieving this goal is explained function-by-function.

1.2 ORGANIZATION

The overall Western Region Applications Program organization for Phase I is identical to that presented in Figure 3 of the Executive Overview. In fact, this organization holds throughout all phases. It is the degree of staffing which may increase with demand and the area of emphasis which will shift from one phase to another.

At the outset, User Awareness will have the greatest burden. Yet its activities must be tempered by the capacity of the remainder of the organization and/or external resources to accommodate the interest generated. There will be a "no promises we cannot keep" approach.

1.3 ANTICIPATED ACCOMPLISHMENTS

The initial technology to be transferred by the Western Region Applications Program will be satellite remote sensing of the Earth's resources, Landsat. Therefore, all anticipated accomplishments will be defined in terms of it.

By fiscal year-end 1978, media utilization will be well underway. The mobile van facility will be on the road and its use tested in the Pacific Northwest Region.

The major anticipated accomplishment within the 14 western state governments by fiscal year-end 1979 would be that:

* each state will have identified, and assessed the potential for development, a primary area of interest in Landsat technology,
* at least one university within each state will be training instructors in Landsat technology.

The timetable for private sector utilization of Landsat on a cross industry basis cannot be predicted; however, the degree to which it accelerates, governmental entities will accelerate. In any case, the goals for the initiation of Phase I will be met by the above accomplishments. That which can be achieved above and enumerated items will be aggressively pursued.

2.0 OBJECTIVES AND RESPONSIBILITIES BY FUNCTION

2.1 OFFICE OF THE DIRECTOR

2.1.1 OBJECTIVES

Clearly the objectives of the Director are to:

* Maximize the number of users and awareness of potential users of NASA-developed technology.

* Oversee as effective and efficient organization as is possible.

Inherent in the achievement of both of these objectives is the goal of responsiveness; responsiveness with maximum competency and minimum bureaucratic procedure. The tie-in bewteen the transfer process and the organizational structure is designed to be the first step in achieving that goal. The use of external resources wherever and whenever possible is another.

Other steps which fall under the purview of the Director are:

* obtaining necessary funding and support.
* incorporating into the basic structure, through over-sight, a dynamic system of assessment and guidance.
* providing the interface for private sector suppliers of services and equipment.

Through judicious use of these tools the stated objectives will not only be met but protection of the public good will be assured. How this will be accomplished will be specificed in the following discussion.

2.1.2 SCOPE OF RESPONSIBILITIES

The executive, managerial, and administrative reponsibilities inherent in any directorship, public or private, will be assumed. The activities to be discussed here are those for which the director is the Western Region Applications Program interface.

2.1.2.1 WRAP Demonstration Center

The key and underlying reason for the Demonstration Center is the need for direct communication between user, potential user and suppliers of services and equipment in an environment of free exchange, i.e., non-government presence. Where technology has not yet been understood or accepted, the opportunities for such exchange are rare and costly for both the potential consumer (if any assessment of offerings is to be made) and the supplier (if a large audience which has not achieved a critical mass is to be reached). The Western Region Applications Program will attempt to provide that critical mass of users, will create an environment in which free interchange can occur, and in turn, will ask industry to provide, as its expense, the materials, personnel or equipment to make this opportunity a reality.

Simply stated, the Demonstration Center will be space and facilities initially provided by WRAP for suppliers to publicize their offerings through displays and handouts, presentation oppotunities, and eventually hands-on demonstrations of equipment. The idea is to have as many vendors housed in the same facility as possible with a rotational mechanism when supply exceeds demand. This will maximize user exposure to a variety of offerings and simultaneously stimulate innovation through competitive exposure. Facilities will also be available for confidential exchange between perspective users and hopeful suppliers.

This is a concept which the users welcome. To grasp which is available in the marketplace under convenient circumstances has always been a goal. Suppliers initially, while receptive to the idea, will approach its implementation cautiously. Displays and promotional materials will be readily available. Guest lecturers for user groups will be fairly easily provided. Coordination of schedules represents the most significant requirement for participation of this type. However, demonstration equipment and on-site personnel represent major investments. They will only be supplied if the depth and scope of interest generated by the Western Region Applications Program justifies the investment and the terms and conditions of installation provide appropriate protection.

This step-by-step approach conforms to a principle inherent in the Western Region Applications Program. Each progressive step and degree of involvement in all functions and phases of the program must be justified by the results of the previous exchange.

To accomplish the goals of the Demonstration Center, suppliers will be sent regular notification of user schedules and profiles. These and other logistics will be resolved as part of the implementation plan, but the intention is to provide these services through external support.

In addition to the user-industry interface, a maximum of seven demonstration center participants elected from the total area will be asked to act as an advisory and review board on the state-of-the-art. Much of the success of the Western Region Applications Program is dependent upon a detailed awareness of what is available in the marketplace and how is it, or can it, be used. The resources of the Western Region Applications Program and NASA itself are too limited to achieve an equitable awareness independently.

Because of rapid changes in non-space technology and new developments as the market grows, it would be advisable for this group to meet four times a year. Membership should include as many differing areas of industry expertise as possible.

This group differs from another proposed group, the Technology Transfer Advisory Council, in that its primary emphasis will be on the details of what is being taught or demonstrated by NASA, the content rather than the process of technology transfer.

2.1.2.2 TECHNOLOGY TRANSFER ADVISORY COUNCIL

The director of a regional technology transfer center cannot be expected to accept the burden of achievement without the benefit of advice and counsel. To provide this, it is essential that a body of experts, not credential seekers, be established to assess direction, results and goals, and provide guidance on how to proceed. It would be necessary for such a body to meet three times a year, issuing interim reports and an annual evaluation. The composition of the body would include representation from all end-user segments, supplier industry, and academia, yet it must be small enough to accomplish its objectives in a short period of time. In order to accomplish representation of all users while maintaining parity among end-users, providing representation of indirect users, and yet limiting size, the following recommendation is made:

* End-User Representation
  - 2 representatives elected by and from the 14 western states
  - 2 federal-user representatives from activities within the 14 western states
  - 2 private sector user representatives from businesses within the 14 states

* Indirect-User Representation
  - 2 supplier industry representatives
    - 1 from the equipment industry
    - 1 from the service industry
  - 1 academia representative from an institution within the 14 states.

Term of participation would be two years.

The work of this body would not only achieve the goal of assuring the public good in Western Region Applications Program activities, but it would provide objective material for the Space Applications Board, for NASA, for Congressional Subcommittees, OMB and the Executive Office.

2.2 USER AWARENESS

The tasks of "reaching out", capturing the attention, imagination and interest of a potential user of any technology are manifold. First a receptive climate must be created. Then the imagination of the intended recipients must be stimulated. Finally, all of the real obstacles, as well as the psychological ones of human inertia and reticense must be overcome. Only then can a willingness to accept innovation, and that is what technology transfer is, be achieved. But in taking that initial step of creating a receptive climate, the current level of understanding must be established. This implies the capacity to respond to opportunities as well as the ability to create them. Thus, the complexities of User Awareness are established.

Assuming the desired environment is achieved, the User Awareness staff will serve as an information clearinghouse and feedback mechanism for news from and about users, industrial developments, university education offerings, and technology achievements. Finally, this group must support awareness activities initiated by users, industrial supplies and universities as well as by the media.

Direct cooperation is essential in projects through which potential users will gain a broad understanding of the technology to be transferred, its applications, and its development. Since this audience is sizable and its information sources diverse, mutliple media is needed to reach users and multiple exposure to help them retain the message. Publicity will be a prime vehicle . . . news about demonstration projects, cooperative relationships, equipment. applications . . . in consumer prints and broadcast media, trade and specialized publications. "Piggybacking" on existing industrial trade shows in a cooperative venture to be utilized. Participation-through speakers, papers, presentations, or displays --in conventions, workshops, or seminars held by professional associations is another.

Public events, museums, even retail outlets may be explored. And in all the communications tools developed for these ventures--publicity materials, literature, films, audiovisual displays--the working principle of user-oriented content, style, and delivery will be exercised.

From this wide audience, of course, will come a smaller group of potential users who have a real and immediate interest in involvement. They require more specific applications information and face-to-face, interactive meetings, with the Western Region Applications Program personnel or other users, to discover what they need to know. The Western Region Applications Program's "technology transfer on wheels" -- the mobile facility--could bring a personal, controlled environment for such meetings right to their doorsteps. Workshops and seminars, with industry and university participation, can do the same. These direct meeting possibilities can be geometrically expanded--and their costs reduced--by using teleconferencing or presentations through CTS or existing wide-flung video networks like the one operated by the Veterans Administration Hospitals Cooperatively--produced materials, especially applications profiles, form a critical backup . . . carrying real case histories to an audience that needs to see results from arenas similar to its own.

Clearly, the execution of all User Awareness activities is largely dependent upon User Assistance, User Liaison, and User Application

Projects, as much as it is on external groups. More exactly, User Awareness will enjoy give-and-take relationships with all of them, and with other Regional Applications Programs and NASA Headquarters, as all work toward successful transfer of technology.

2.3 USER ASSISTANCE

2.3.1 OBJECTIVES

The objective of User Assistance is to provide technical assistance in developing a clear understanding of the uses of, and approaches and equipment for applying, NASA-developed technology. This technical assistance will include not only direct involvement in the technology and equipment provided by the Western Region Applications Program's facilities and the Demonstration Center, but university course work and help in defining specific programmatic and data needs, and technical guidance in program planning. In other words, User Assistance means helping the potential user to assess the technology and, where its use is justified, get his own program underway.

2.3.2 PHILOSOPHY/SCOPE

As elsewhere in the plan, the Western Region Applications Program group will act as the catalyst, the coordinator and the supporter rather than the implementor of assistance in so far as possible. This will be achieved by:

* WRAP training of university instructors in the technology and equipment to fill the gap between user needs and courses available at EROS

* soliciting of presentations to user groups by experts for service and equipment suppliers, both in general course work and specific applications.

* providing the opportunity for hands-on training at the Western Region Applications Program facility, in the mobile van facility and hopefully in the Demonstration Center.

When the Demonstration Center is equipped by a variety of suppliers and their personnel, it should become the greatest single asset to technology transfer available in the Western Region Applications Program. It will bring together the elements necessary for on-going use of technology -- users, suppliers and educators.

Incorporated in the philosophy of User Assistance is the conviction that the maximization of working group involvement both at managerial and staff levels and a clear definition of specific assistance functions are essential to the achievement of technology transfer. In providing the assistance function and attempting to insure total user department or agency involvement, each activity will seek to establish the user's ability to perform, independent of NASA, all on-going requirements, including in-house training.

In-so-far-as capacity permits, User Assistance will accommodate all potential users.

2.3.3 DUTIES AND RESPONSIBILITIES

User Assistance has responsibilities in three main areas:

* Training,
* Technical assistance,
* User services,

each of which will be discussed here.

2.3.3.1 TRAINING

As already stated the initial responsibility of User Assistance is the training of university instructors in the technology. The goal is to establish expertise and curriculum in at least one university within each of the 14 western states. However, since the overwhelming responsibility of the Program is to potential users, university training will be conducted concurrently with users at the outset. As the universities assume their teaching roles, the Western Region Applications Program will correspondingly reduce its activites in these areas.

Every effort will be made to tailor the courses to the user group in attendance while maximizing total enrollment to achieve the economies of scale. Items related to the use of a given technology will be identified and included in the training wherever feasible and practical.

During this initial phase of technology transfer, the Western Region Applications Program plays a major training role. This role should shift to academia and industry as the transfer process progresses, leaving the Applications Program free to assume the responsibilities of another NASA-developed technology.

2.3.3.2 TECHNICAL ASSISTANCE

Technical assistance will be provided by the User Assistance group in a variety of areas. This group serves as a pipeline to and from User Applications Projects and as such must identify such potential projects and work with User Liaison to assure a thorough understanding by the user of their implications and responsibilities. It will also serve as a Federal interagency communications vehicle and provide planning and implementation assistance, and special seminars and briefings using its discipline specialists staff.

2.3.3.3 USER SERVICES

User Assistance will assist in the production of documentation of Applications Projects and publications addressing the technology, its technology transfer process and user activites. It will maintain a reference library at the WRAP facility for the use of personnel and guests. A tour service, including technology demonstrations, will be available to vistors to the facility. Such tours will be coordinated to include the Demonstration Center.

2.3.4 DEPENDENCIES

The most obvious determinant of achievement will be the limitations placed on training capacity/enrollment by budgetary and timing constraints. But beyond these items which area always present, the development of, and industry and user contribution to, a national data bank of application case histories is essential to an efficient transfer of technology. Such case histories provide the realism in the User Assistance process.

2.4 USER LIAISON

2.4.1 OBJECTIVE

The major focus of the user liaison function is the maximization of opportunities for public agencies, and private enterprises within the 14 western states to evaluate NASA-developed technology.

The emphasis is on public agencies where identifiable targets are readily available and procedural mechanisms can be established on a state-by-state basis as opposed to establishment-by-establishment. Each state will be given the opportunity to test the technology against its statutory and operational needs.

2.4.2 PHILOSOPHY AND STRATEGY

The basic philosophy which drives the Western Region Applications Program

is that all activities must be user driven. By implication, the initial and key element of the program must be an effective mechanism for communicating with the entire potential user community with the region.

In interfacing with the state and local governments, the strategy for liaison activities will be to utilize the expertise of a person familiar with the workings of state and local government within the region being served and to identify a key contact person within the jurisdiction. This strategy calls for a "top down" approach, e.g., starting with the appropriate elected official (or his or her immediate staff), moving to agency heads and, as appropriate, down through the agency structure. It also calls for each level of management to decide if it is appropriate to proceed further.

In the "perfect" case, thus decision will be based on:

(1) the credibility of NASA and the Western Region Applications Program

(2) the thoroughness of the exposure to the technology provided by the Program, and

(3) the appropriateness of the technology to the real, or perceived, needs of the jurisdiction.

Experience in the Pacific Northwest has shown that unless each managerial level is satisfied on each item, an actual demonstration project or independent operational test will not, and should not, be undertaken. Conviction to proceed is paramount to future operational implementation. It is the primary responsibility of the liaison staff to see that items (1), (2), and (3) are achieved in the decision-making process.

2.4.3 ORGANIZATION AND RESPONSIBILITIES

The liaison function will be organized around a Regional Liaison Officer-someone thoroughly knowledgeable in the inner workings of state and local government, the more cumbersome and rigid environment in which to function. It will be the responsibility of these individuals to be "translators" between those whose mission is training, assistance, demonstration, and feedback within the Program, and the users.

Eventually, each of the federal regions encompassing the 14 states (Regions VII, IX, and X) will have a liaison officer working and physically residing within the region. This is of primary importance. An individual with "inside" credentials, stationed within the sector, will be perceived positively by state and local officials. Throughout the program, it will be important for the liaison to be identified as an ombudsman who can solve potential user problems and be both translator and buffer between NASA and the user community.

As the number of states actively involved in the Program increases, the number of individuals performing this function in it increase. Initially, the Program will start by dividing the states into two sectors, the northern and southern, and assigning two Liaison Officers.

2.4.4 DEPENDENCIES

There is a heavy burden upon the liaison officer because of the tremendous dependencies on the rest of the organization for accomplishment. For example, it would be counter-productive to move a state or agency toward a possible demonstration and then not be able to honor the commitment, whether implicit or explicit! If one examines the past history of attempted technology transfer with Landsat, the only states with meaningful commitments to operational use, albeit somewhat tentative, are those which have had a broad spectrum of potential user agencies and their personnel involved in a series of demonstrations. By contrast, the private sector is quite capable of independent action once necessary information and preliminary assistance is provided.

2 5 USER APPLICATIONS PROJECTS

2 5.1 OBJECTIVE

Once liaison and training have been established, the focal element of the Western Region Applications Program will become the User Applications Projects group. The objective of this group is to work with users in organizing and performing demonstration projects as devices for assessing the operational value of NASA technology To state it another way, the objective is to provide the potential user with the opportunity to prove the value of the technology in the solution of a real problem in its actual environment The potential users will be moved closer to the reality of actual users, closer to a success in technology transfer.

2.5.2 PHILOSOPHY AND STRATEGY

The general philosophy in conducting demonstration projects is that the user must be "walked" through the solution to one or more sample problems in a highly supportive environment with ample and increasing opportunities for totally independent functioning. It is during this process that understanding of the technology can be assessed as well as the potential value of the technology estimated.

In keeping with the basic tenets of the Western Region Applications Program, specific tasks within each Applications Project will be offered to private industry on a competitive, fixed price basis. This will not only encourage private industry involvement, but it will increase user-supplier interfaces Based upon previous experience, sufficient resources must be available to undertake a minimum of four discipline demonstrations for each state in which pursuit of a technology is successfully initiated. In most cases, the existence of a previous success elsewhere in a demonstration project alone will not obviate the need for direct participation with a new user

Whenever possible, User Application Projects will attempt to demonstrate multiple NASA-developed technologies in a single effort. For example, between November 1977 and May 1978, the

Mobile Analysis and Telecommunications Experiment will attempt to demonstrate the feasibility of conducting Landsat image analysis with a remote interactive video terminal through both satellite communications and land line telecommunications systems. Various communications and processing strategies will be tested. Insights gained in experiments such as this one, as well as those provided by the participants in the Demonstration Center will be passed on to subsequent potential users to shorten the cycle to operational.

2.5.5 ACCOMPLISHMENT AND DEPENDENCIES

Each User Applications Project will be documented for future reference by this and other users, WRAP personnel, NASA Headquarters and other Regional Applications Programs, and industry. WRAP personnel will work with the user to document the problem description, solution techniques attempted or used, their success or failure and an assessment of the potential value of the technology for this particular use The value of this documentation to the total program is of such magnitude that it makes every User Applications Project, regardless of outcome, a success.

The major dependency of User Applications Projects is the availability of participation by a variety of equipment and service suppliers willing to provide fixed-price services and work on a task rather than project basis.

III PHASE II - CO-EXISTENCE

1.0 OVERVIEW

As stated in the executive overview, Phase II of technology transfer is that intermediate period during which a sufficient body of experienced users exist to assist in the process itself, not through any formalized or institutionalized structure but as the outgrowth of their normal activities. Involvement of the Western Region Applications Program will remain always cooperative with these users, but its role shifts from one of initiation to one of support as awareness moves through successive stages to operational systems. Support of "user-driven" User Awareness is essential; users learn best from each other's experiences and results, not from NASA's. (Referencing an earlier statement only the user can transfer technology.) That belief leads to a commitment that content, style, and delivery of User Awareness will center on users talking to users, universities addressing each other, and industry passing the word.

This working principle lends itself to better understanding; a user, for instance, automatically addresses a potential user's question, "What does this mean to me?" It also lends itself to more efficient communication. As more potential users become aware, the Western Region Applications Program cannot shoulder the entire responsibility. As an outgrowth of this sharing of experience, new uses and better techniques will develop, improved performance requirements will be identified, and the continuity of the program assured.

As part of the support provided to users during this phase, User Liaison will assist operational networks in providing demonstrations to potential users within the state or across state boundaries. This function will also coordinate resources in facilitating the transition from demonstration applications to operational environments in those states and agencies where an implementation decision has been made.

Because there still remains a large base of potential users, the activities of User Assistance will not substantially change. In Training, greater use will be made of case histories and user references. These will be made available to academia as quickly as possible since they should be firmly established in training by this period. In fact, assistance in documentation of completed demonstrations and users experience becomes a major activity for User Assistance.

At this point in time, the Demonstration Center should be fully equipped by Industry and they should be conducting a very productive interchange with users independent of WRAP activities. Their support

Their support of WRAP activities will not be eliminated.

As demonstration projects reach their conclusion, the User Applications Projects group will concentrate on assistance in analysis of results and approaches for transition to operational. This group will be able to feed valuable information into all aspects of the system - NASA development, user guidance, industry guidance, academic knowledge - as a result of these analyses.

This is an exciting period. It is the make or break point for any technology. If experience shows that use cannot be justified without modification or new direction, pursuit of the "as is" should be abandoned.

IV. PHASE III - USER DIRECTED

1.0 OVERVIEW

Assuming a given technology has been accepted and put into operation, its use will mature to the point of inadequacy or obsolescence. Before this point is realized, the mechanisms must be in place, and working, to assure the technology keeps pace with the users. Exercising these mechanisms is the major focus of the Western Region Applications Program during this phase. Clearly, there are few initiatives that will be made by WRAP during this period that are not in response to user experience or demands.

While User Awareness will continue to emphasize the value achieved by users, it will also highlight how greater value can be attained. User Liaison and Assistance will find itself more and more in a feedback mode of operation. At times, the feedback will be directed at industry rather than NASA when equipment and/or services are insufficient to support the full potential of the technology. These requirements will be passed to industry, as will be done with academia in the case of educational requirements.

In the case of User Applications Projects, this period offers three new responsibilities

(1) verification of the inability of current technology to handle the user requirement cost-effectively
(2) validation of the cost justification for this application
(3) working with the user, documentation and transmittal of each new requirement to NASA applications development, and, upon receipt of its disposition from Headquarters, transmittal back to the user.

Thus, the feedback system will be complete and the technology will become user-directed.

The phases delineated in this plan will generally be experienced by each technology. But it should be emphasized here that no attempt will be made to synchronize technologies by phase. In other words, the Western Region Applications Program is prepared to handle multiple technologies in differing phases, as stated in the Executive Overview.

V. SUMMARY OF WESTERN REGION APPLICATIONS PROGRAM

GENESIS:

NASA enactment charter -

National Aeronautics and Space Act of 1958

(72 STAT. 426; 42-U.S.G. 2451 SEQ) as amended.

KEY PHILOSOPHY.

User-driven technology transfer program based on the establishment of interpersonal relationships in developing competency.

UNDERLYING PHILOSOPHIES:

* A backbone of expertise within NASA supplemented by contracted services enabling flexibility and cost effectiveness as multiple technologies are approached.

* Direct interface between users and supplies wherever possible.

PHASES OF TECHNOLOGY TRANSFER:

(Determinants of approach):

* Initial Phase - Technology
* Intermediate Phase - Co-existence between technology and user experience.
* Final phase - User experience.

COMPOSITION OF EACH PHASE OF TECHNOLOGY TRANSFER AND THE WESTERN REGION APPLICATIONS PROGRAM ·

Awareness

Liaison

Training and Assistance

Applications Projects (Demonstrations)

Applications Systems (Technical Support)

PERFORMANCE RESPONSIBILITY OBJECTIVES.

See Figure 4.

TARGETS OF TECHNOLOGY TRANSFER WITHIN 14 WESTERN STATES:

Potential users in:

Federal

Regional, State, and Local

Private

Sectors

PERFORMANCE RESPONSIBILITY OBJECTIVES

FUNCTION	NASA	ACADEMIA	INDUSTRY
Awareness	X		
Liaison	X		
Training:			
Trainers	X		
Users		X	X
Equipment			X
Applications Projects.			
Management	X		
Coordination	X		
Technical Support			X
Follow-up	X		

FIGURE 4

ATTACHMENT A

CHARACTERISTICS OF PROGRAM PLAN

* Organization with ability to handle multiple technologies
* Mechanisms for external guidance and assessment
* Flexible, cost-effective approaches providing base for future developments
* Immediate start with Landsat technology
* Early introduction and encouragement of industry participation
* Industry demonstration center - Independently administered
* Mobile van facility
* User technology assessment and reporting system
* University participation in training

ATTACHMENT B

WRAP DEMONSTRATION CENTER IMPLEMENTATION PLAN

Step 1.

Identify and obtain the support of a non-proft, non-governmental organization having substantial industry connections and/or interests to administer the participation of industry in a demonstration center facility provided by the Western Region Applications Program for the benefit of free exchange and direct interface between potential users of a technology and the suppliers of equipment and services.

Step 2.

Obtain an agreement on the services to be provided. Those desired include

a. Announcement of opportunity to potential participants (announcement letter clearly defining the nature of the opportunity and a list of known targets will be supplied by WRAP.)

b. Coordination of participation. There are space and facilities limitations at WRAP as well as "length of commitment" limitations within industry which must be coordinated. In addition there must be an intermix of equipment and services.

c. Preparation of a quarterly supplier participation calendar for WRAP.

d Transmittal of monthly WRAP visitor and user activity schedules to industry. (These schedules will include the name and telephone contact within WRAP for each activity, so that follow-up will not be part of the required service)

e Maintenance of listings (by Company, address, telephone number and contact) of all approached and contact status: participation, rejection, no reply, etc.

f Demonstration Center Advisory Review Board election. Using the guidelines provided by WRAP, conduct an election among the participants to form this board.

Step 3

Negotiate term for which services will be provided

Step 4.

Determine funding required for services provided and mode of reimbursement

Step 5.

Proceed upon implementation of Western Region Applications Program Plan.

ATTACHMENT C

QUESTIONS AND ANSWERS ON TECHNOLOGY TRANSFER ARRANGEMENTS WITHIN THE WESTERN REGION APPLICATIONS PROGRAM.

Q. Is the WRAP organization interim or permanent?

A. The organization presented cannot be classified as interim or permanent because it will be shaped and reshaped by experience.

Q. What are the types of participation in the program?

A. NASA, Academia, and Industry offering a spectrum of services from General Awareness to Hands-on Training and Feedback to Potential and Current Users from the Federal, Regional, State and Local, and Private Sectors.

Q. Is there a separation or integration between development (NASA) and Use (Users)?

A There is a healthy separation in that WRAP will not perform the users job. There is an ideal integration in that WRAP will provide training and assistance utilizing those resources which have the on-going mission within our societal structure - academia and industry. The integration goes a step further by providing the mechanism for incorporating users' on-going requirements into future development determinations.

Q. How will the effort be financed and controlled?

A. The broad efforts of technology transfer will be financed by NASA. These specific tasks contracted to Industry or Academia will be controlled by NASA. All other areas, even those where NASA provides specific encouragement of direct user-supplier interface, will be free of control.

Q. How will the process be managed?

A At the national level of management, NASA Headquarters will hold periodic reviews At the WRAP level, the Program and Functional Directors and Officers will manage the process with the benefit of guidance and review by the WRAP Technology Transfer Advisory Council.

Q. Will all sectors have access to the organization as well as the technology?

A. Yes, but the primary emphasis will be on State and local governmental entities which have less flexibility and fewer perogatives in obtaining the services offered by the organization.

NASA's Western Regional Applications Program:

What Does It Mean to You?

The data crunch is here.

And you know how it feels Today, you need more information than ever before about your state's natural resources from impact statements to monitoring data The question is, how do you get it?

Landsat may be part of the answer.

WRAP is set up to work with you . to find out whether Landsat data can help you make better decisions about natural resource management for your state And if it can, we'll help you incorporate Landsat into your data collection operation

We don't pretend that Landsat is the sole solution to *all* your problems Or that it's automatically more economical, faster, and better data than you're getting now But it *is* a tool that may help you in your decision-making

Landsat deserves a test. And that's just what it gets.

We call them demonstration projects . small-scale, clearly-defined programs to test whether Landsat works for you We'll work with you to set up a training and demonstration project defined by what you need to know

You're the leader . . . but it takes two to tango.

You're the user When we call our program "user-driven," that means you tell us what you need In data, in training, in assistance We tell you how, when, and where we can provide those. Together we'll determine who will contribute what people, money, and information Then we carry on a training and demonstration project At the end of that, we share the evaluation and if it shows that Landsat data makes sense for your state agency needs, we'll help you merge remote sensing into your operating system

WRAP's not in this for you. We're in it with you.

Sure, there are lots of hurdles to overcome in a program like this After all, nobody's really launched a user-driven technology transfer project on a large scale before The point is, that if we work together, we can work it out We think it's worth trying We hope you do, too

Give WRAP a buzz . . . for more information about:

User assistance and training:	Dr. Robin Welch NASA Ames Research Center Mail Stop 240-4 Moffett Field, CA 94035 415/965-5232
Liaison, meetings, news of users in northern states:	Mr. Mike McCormick Washington State Office of Community Development Room 400, Capitol Center Bldg. Olympia, WA 98504 206/753-2203
Technical assistance in applications:	Dr. Dale Lumb NASA Ames Research Center Mail Stop 242-2 Moffett Field, CA 94035 415/965-5900
Publicity, conferences, literature, films:	Phoebe Williams NASA Ames Research Center Mail Stop 240-4 Moffett Field, CA 94035 415/965-5232
The Western Regional Applications Project in general:	Mr. Ben Padrick NASA Ames Research Center Mail Stop 240-4 Moffett Field, CA 94035 415/965-5285

THE CENTER FOR COMMUNITY DEVELOPMENT

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TOM PARSONS
Director

American Indian Communities TV Project

American Indian Languages and Literature Program

Community Education Project

Humboldt Co Recreation Project

Indian Mainstream Industries Project

Kotim Een Karuk Ceremonial Society

Multi Cultural Education Project

N A S A Remote Sensing Technology Transfer Project

National American Indian Repertory Theatre Project

Northern California Health Systems Agency Support Project

Redwoods Community Development Council Project

Wood for Seniors Project

SUMMARY REPORT ON THE CONFERENCE OF REMOTE SENSING EDUCATORS (CORSE-78)

SPONSORED BY

NASA AMES RESEARCH CENTER

AND

WESTERN REGIONAL APPLICATIONS PROGRAM (WRAP)

SUBMITTED BY:

ROBIN I. WELCH
CONFERENCE CHAIRMAN

AND

DIRECTOR,
USER ASSISTANCE
WESTERN REGIONAL APPLICATIONS PROGRAM

JULY 1978

IN COOPERATION WITH CALIFORNIA'S NORTHWEST COUNTIES

572

Highlights

CONFERENCE OF REMOTE SENSING EDUCATORS (CORSE-78)

June 26-30, 1978

Sponsored by

NASA Ames Research Center

and

Western Regional Applications Program (WRAP)

Conference Chairman: Robin I. Welch

Host: Dean E. I. Rich,
Department of Earth Sciences
Stanford University

Collaborators in Sponsorship:

U.S. Geological Survey - EROS Program
Association of American Geographers
American Society of Photogrammetry

The Conference was dedicated to improving the teaching of remote sensing technology and related subjects for earth resources management and environmental monitoring in colleges and universities.

The Objectives of the Conference were. (1) To enhance and encourage the teaching of remote sensing, both in formal courses and in workshops or short-courses, (2) To promote interaction of faculties and exchange of ideas so as to increase the effectiveness of remote sensing training and education; (3) To consider curriculum requirements and faculty qualifications; and (4) To facilitate cooperation between Government, industry users and academic institutions in meeting the aforementioned objectives.

To encourage and stimulate participation, especially by college and university professors with minimum experience in remote sensing technology, CORSE was operated on a budget of $60,000 under a policy of providing transportation and honoraria to all speakers and workshop panel memebers and providing room and board on campus for all faculty representatives within the WRAP region

Registered conferees came from the following groups:

University & State Colleges, WRAP Region	83
Outside of Region	5
Community Colleges	8
Commercial and Professional	9
State & Federal (Non-NASA)	6
NASA/ARC	28
Foreign	1
Other Non-University	2
TOTAL	142

Of the people initially indicating intent to participate, only 35 did not show.

Seven exhibitors had displays at the Conference. In addition to Ames Research Center, the EROS Data Center and the U.S. Geological Survey, Menlo Park, other exhibitors included: Bausch & Lomb, Inc., Interpretation Systems, Inc., LARS-Purdue University, Pilot Rock, Inc., and Spatial Data Systems, Inc

Accomplishments. In the opinion of the WRAP staff and three independent summarizers who participated in the Conference, contributions to each objective were substantial, and some unanticipated benefits were realized. It was generally conceded that an effective mechanism for improved communication among the academic groups and between them and NASA was realized through the Conference. Interest in a follow-on is high. The Conference was particularly effective in bringing many interested academicians more up-to-speed in remote sensing or in giving them a better appreciation of education-training needs and opportunities

The Conference achieved an acceptable compromise in serving the interests of both the interested neophytes, represented in some cases by the participants from community colleges as well as those from institutions engaged in intermediate levels of involvement. The old heads and advanced universities probably benefited greatly by dialogue with beginners and intermediates and a realization of what they could do to bring these latter groups into the team with maximum effectiveness.

One spontaneous resolution, signed by 14 faculty members, was turned over to the Conference Chairman. It includes some excellent suggestions for NASA's consideration.

Participants were enthusiastic and impressed by an opportunity to tour the NASA Ames facility. This seemed to significantly boost enthusiasm.

With Bob Barlow and Nick Short representing the other RAP regions, an effective conference of training staff officers was held. The three regional training programs and plans were reviewed, initial coordination effected and plans for continuing dialogue laid.

Perhaps the most beneficial element to come out of the Conference will be the Proceedings and especially the dialogue from the numerous Workshop Sessions which included (1) Deliberations by sub-regional groups within the WRAP area, (2) Deliberations on data acquisition and reduction and multimedia techniques in training and teaching, (3) Disciplinary academic workshops in forestry, range and environment, geology/geophysics, agriculture, soils and hydrology; geography, urban planning and land-use; and in oceanography and water resources.

It is particularly significant to recognize that CORSE-78 generated a strongly-enhanced level of both enthusiasm and momentum for progress. It is vitally important that NASA be responsive to this new situation with positive follow-on program elements. These must respond effectively to the training and education needs of academia in the technology transfer process. Given such support, CORSE-78 will clearly be a turning point in achievement, not just anotner conference with proceedings to gather dust in the archives.

It was often repeated by conferees that substantial progress in education could be realized by merely giving already involved instructors better working materials. A significant training program for newly involved instructors was also a generally recognized need. Response to both these needs will enable NASA to greatly multiply its training staff and realize a critical mass in training-education manpower.

The University Advisory Committee, organized under contract to the University of California at Santa Barbara, met in evenings during the Conference. The representation base was expanded and substantial gains were realized toward committee tasks and the goal of organizing a Remote Sensing Science Council among universities in the WRAP area.

CORSE-78

ATTENDEES

NAME/COLLEGE, UNIVERSITY OR AFFILIATION	CAMPUS RESIDENT	NON-CAMPUS RESIDENT
Aamodt, Melvin H. California State College, Stanislaus	X	
Arunkumar, Prof. University of California, Los Angeles	X	
Ashley, Joseph M. Montana State University	X	
Atkinson, Natalie O. Oceanic Society, San Carlos, CA		X
Atwater, Sue University of California, Santa Barbara		X
Avera, Harmon Q. Bausch & Lomb, Fullerton, CA		X
Barlow, Robert NASA/Earth Resources Lab	X	
Bauer, Ethel NASA Ames Research Center		X
Bell, Earl J. University of Washington	X	
Benson, Gilbert T. Portland State University	X	
Berg, Richard Huxley College	X	
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Briggs, Ben NASA Ames Research Center		X
Brimmer, Roger NASA Ames Research Center		X
Butler, Camille NASA Ames Research Center		X
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Chow, Willard (Tim) University of Hawaii	X	
Colcord, J. E. University of Washington	X	
Colwell, Robert N. University of California, Berkeley		X
Conrey, Bert L. California State University, Long Beach	X	
Cornwell, Ms. Sally Bay Office of Planning & Research, Sacramento, CA		X
Cubila, Bill Olympic National Parks Headquarters		X
Dando, William A. University of North Dakota	X	

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Estes, Dr. Jack University of California, Santa Barbara		X
Ezra, C Elaine University of California, Santa Barbara		X
Finch, Dr. William San Diego State University	X	
Floyd, Donald R. California Polytechnic Univ., San Luis Obispo	X	
Fox, Lawrence III Humboldt State University	X	
Frazier, Bruce E Washington State University	X	

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Grundborg, Robert B. NASA Ames Research Center		X
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Hall, Julie I. Pilot Rock, Arcata, CA		X
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Kiefer, Ralph W. University of Wisconsin		X
Knothe, Kenneth Treasure Valley Community College	X	
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Lauer, Donald T EROS Data Center		X
Lee, Chung-Myun University of Utah	X	
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Maxwell, Eugene L. Colorado State University	X	
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Poulton, Charles E. NASA Ames Research Center		X
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Russell, J. Johnson Mission College, Santa Clara, CA		X
Sabins, Floyd F. University of California, Los Angeles	X	
Schlosser, M. S. Spatial Data Systems, Goleta, CA		X
Schowengerdt, Robert University of Arizona	X	
Schrumpf, Barry Oregon State University	X	
Schultz, Robert J. Oregon State University	X	
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Sharp, James M. University of California, Berkeley		X
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Smith, Dr. James A. Colorado State University	X	
Spencer, Page University of Alaska	X	
Stewart, Moyle D. USGS, Menlo Park		X
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Strohman, Rollin California Polytechnic Univ., San Luis Obispo	X	
Syvertson, C. A. NASA Ames Research Center		X
Tabor, Janet University of California, Santa Barbara	X	
Taube, Donald W. University of California, Santa Barbara		X
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Turner, Brian Penn State University	X	
Tyley, Steve USGS, Menlo Park		X
Ulliman, Joseph J. University of Idaho	X	

1d

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Washburn, Gary M. San Bernardino Valley College	X	
Weinstein, Richard NASA Headquarters		X
Welch, Robin I. NASA Ames Research Center		X
Welch, Thalia Conference Hostess		X
Westerlund, Frank V. University of Washington		X
Westin, Frederick South Dakota State University	X	
Whitmore, Roy A., Jr. University of Vermont		X
Williams, Phoebe L. NASA Ames Research Center		X
Wingert, Everett University of Hawaii	X	
Wrigley, Robert C. NASA Ames Research Center		X

CONFERENCE OF REMOTE SENSING EDUCATORS

CORSE-78

Formal Papers and Working Sessions

June 26-30, 1978

Kresge Auditorium
Stanford University
Palo Alto, California

Sponsored by

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California
Western Regional Applications Program (WRAP)

Conference Chairman Robin I Welch

Hosted by

Dean E. I. Rich, Department of Earth Sciences
Stanford University

In collaboration with

U.S Geological Survey - EROS Program
Association of American Geographers
American Society of Photogrammetry

Dedicated to improving the teaching of remote sensing technology and related subjects for earth resource management and environmental monitoring at colleges and universities. Emphasis will be on teaching techniques, materials, graphics, field exercises, curricula, faculty qualifications, and support facilities, equipment and services.

NASA AMES RESEARCH CENTER

Conference of Remote Sensing Educators
(CORSE-78)

June 26-30, 1978

Stanford University

Day	Time	Subject
June 26 Kresge Auditorium	9:00 - 9:35 a.m.	Introduction/Welcome--Dr. C. A. Syvertson, Director, Ames Research Center, Professor Francis H. Moffitt, First Vice President, American Society of Photogrammetry; Mr. Donald T. Lauer, Chief, Applications Branch, EROS Data Center, USGS, Dr. John Estes, American Association of Geographers
	9·35 - 10.00 a.m.	Problem Statement--Dr. Robin I. Welch, Western Regional Applications Program, NASA Ames Research Center
	10:00 - 10:15 a m.	Coffee Break
	10.15 - 11:30 a.m.	Key Note--History and Future of Remote Sensing Technology and Education; Dr. Robert N. Colwell, University of California, Berkeley
Wilbur Hall	12:00 - 12·30 p.m.	Lunch
Kresge Auditorium	1.00 - 2 00 p.m	Attributes of a Well-trained Remote Sensing Technologist, Dr. John Estes, University of California, Santa Barbara
	2:00 - 2.15 p.m.	Coffee Break
	2 15 - 3 15 p.m.	A Multidisciplinary Approach to Remote Sensing Education, Dr. Philip N. Slater, University of Arizona
	3 15 - 4.00 p.m.	Remote Sensing Research Activities Related to Academic Institutions; Dr. Victor I. Myers, South Dakota State University

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Day	Time	Subject
June 27 Kresge Auditorium	8·45 - 9.30 a.m.	NASA Regional Applications and University Affairs Programs; Mr. Floyd I. Roberson, NASA Headquarters
	9 30 - 10.00 a.m.	NASA Western Regional Applications Program, Dr Dale Lumb, NASA Ames Research Center
	10.00 - 10 15 a.m.	Coffee Break

Day	Time	Subject
June 27 (cont'd)	10:15 - 10:45 a.m.	NASA Western Regional Applications Program Training Activity; Dr. C. E. Poulton, Western Regional Applications Program, NASA Ames Research Center
Kresge Auditorium	10:45 - 11.00 a.m.	NASA Central Regional Applications Program; Mr. Bob Barlow, Earth Resources Laboratory, Slidell, LA
	11:00 - 11:15 a.m.	NASA Eastern Regional Applications Program Training Activity; Dr. Nicholas Short, Goddard Space Flight Center
	11:15 - 11:50 a.m.	Opportunities and Problems in Introducing or Expanding the Teaching of Remote Sensing in Universities; Dr. Eugene Maxwell, Colorado State University
Wilbur Hall	12:00 - 12:30 p.m.	Lunch
Kresge Auditorium	1:00 - 1:45 p.m.	Developing Curricula for Remote Sensing Educators; Dr. John Russell, West Valley Community College, Mission Campus
	1:45 - 2:30 p.m.	The Use of Multimedia and Teaching Machines for Remote Sensing Education; Dr. Joseph Ulliman, University of Idaho
	2:30 - 2:45 p.m.	Coffee Break
	2:45 - 3:45 p.m.	Textbooks and Technical References for Remote Sensing Education; Dr. Stanley Morain, University of New Mexico; Dr. Robert N. Colwell, University of California, Berkeley; Dr. John Estes, University of California, Santa Barbara; Dr. Leonard Bowden, University of California, Riverside; Dr. Robert Rudd, University of Denver
	3:45 - 4:15 p.m.	Short Courses and Special Support Activities at the EROS Data Center; Mr. Donald Lauer, Sioux Falls, SD

June 28 (morning)	8:30 - 12.00 p.m. (Concurrent sessions)	Workshop--Regional Academic Groups
Kresge Auditorium		1. Southern California, Arizona: Dr. Leonard Bowden, University of California, Riverside, Dr. David Mouat, University of Arizona; Dr. John Estes, University of California, Santa Barbara; Dr. Donald Post, University of Arizona; Dr. William Finch, Jr., San Diego State University
J. Henry Meyer Memorial Library, Forum Room		2. Northern California, Hawaii: Dr. Larry Fox, Humboldt State University; Dr. Robert N. Colwell, University of California, Berkeley; Dr. Everett Wingert, University of Hawaii; Dr. Sen-dou Chang, University of Hawaii

Day	Time	Subject
June 28 (morning)	8:30 - 12.00 p.m. (Concurrent sessions)	Workshop--Regional Academic Groups
Tresidder Memorial Union, Room 270		3. Central States--Nevada, Utah, Colorado, Wyoming: Dr. Jack Ives, University of Colorado; Dr. James Smith, Colorado State University; Dr. Lawrence M. Ostresh, University of Wyoming, Dr. Merrill Ridd, University of Utah; Maj. Charles Smith, Air Force Academy
Tresidder Memorial Union, Room 271		4. Northwestern States--Alaska, Washington, Oregon, Idaho: Dr. R. Duane Shinn, University of Washington, Mr. John Miller, University of Alaska; Dr. Barry Schrumpf, Oregon State University; Dr. Joseph Ulliman, University of Idaho; Dr. Bruce Frazier, Washington State University
Tresidder Memorial Union, Room 132		5. Northeastern States--Montana, North and South Dakota: Dr. Frederick Gerlach, University of Montana; Dr. W. A. Dando, University of North Dakota; Dr Victor Myers, South Dakota State University, Dr. Joseph Ashley, Montana State University
Wilbur Hall	12 00 - 12:30 p.m.	Lunch

June 28 (afternoon)	1:00 - 5:00 p m.	Workshop--Data Acquisition and Reduction and Multimedia Groups
&		(Concurrent sessions repeated at 4-hour intervals)
June 29 (all day)	8:30 - 5:00 p.m.	
Kresge Auditorium		1. Data Acquisition: Dr. John Estes, University of California, Santa Barbara; Mr. John Miller, University of Alaska; Dr. P. N. Slater, University of Arizona, Dr. John Taylor, Montana State University
Tresidder Memorial Union, Room 270		2 Data Reduction by Computer Processing Dr Dale Lumb, Western Regional Applications Program, NASA-Ames Mr D Wayne Mooneyhan, Earth Resources Lab, Dr Nevin Bryant, Jet Propulsion Lab; Dr. R. A. Schowengerdt, University of Arizona
J Henry Meyer Memorial Library, Forum Room		3 Data Reduction by Visual Means--Photo Interpretation: Dr. Robert N. Colwell, University of California, Berkeley, Dr. Barry Schrumpf, Oregon State University, Dr. C E. Poulton, Western Regional Applications Program, NASA Ames Research Center

Day	Time	Subject
June 28 (afternoon) & June 29 (all day)	1:00 - 5.00 p.m. / 8 30 - 5:00 p.m.	Workshop--Data Acquisition and Reduction and Multimedia Groups (Concurrent sessions repeated at 4-hour intervals)
Tresidder Memorial Union, Room 271		4. Multimedia Educational Aids and Use of Machine-Aided Teaching Methods: Dr. Joseph Ullman, University of Idaho; Professor Ronald Danielson, University of Santa Clara
June 28	6:00 - 7:00 p.m.	Cocktails preceding Conference Banquet
Faculty Club	7:00 p.m.	Conference Banquet: Banquet Speaker--Dr. Ida Hoos, University of California, Berkeley, CA: "Is Remote Sensing Far Out?"
June 30 (Concurrent sessions)	8.30 - 2:00 p.m.	Workshop--Discipline Academic Groups
Kresge Auditorium		1. Forestry, Range, Environment and Ecology: Dr. C. E. Poulton, Western Regional Applications Program, NASA Ames Research Center; Dr. Barry Schrumpf, Oregon State University; Dr. Frederick Gerlach, University of Montana, Dr. Paula Krebs, University of Alaska
Tresidder Memorial Union, Room 271		2. Geology/Geophysics: Dr. Floyd Sabins, University of California, Los Angeles; Mr. John Miller, University of Alaska; Dr. C. E. Glass, University of Arizona; Dr. Joseph Lintz, Jr., University of Nevada
J. Henry Meyer Memorial Library, Forum Room		3 Agriculture, Soils and Hydrology: Dr. Don Moore, South Dakota State University; Dr. Robert N. Colwell, University of California, Berkeley; Dr. Fred Westin, South Dakota State University, Dr. D. F. Post, University of Arizona
Tresidder Memorial Union, Room 270		4. Geography, Urban Planning, Land Use: Dr. Merrill Ridd, University of Utah; Dr. Nevin Bryant, Jet Propulsion Lab; Dr. David A. Mouat, University of Arizona, Dr. Sen-dou Chang, University of Hawaii; Dr. Willard (Tim) Chow, University of Hawaii
Encina Commons, Room 423, Fourth Floor, West Wing		5. Oceanography, Water Resources: Dr. Victor T. Neal, Oregon State University; Dr. John Estes, University of California, Santa Barbara; Mr. Kenji Nishioka, NASA Ames Research Center, Mr. Robert Wrigley, NASA Ames Research Center

Day	Time	Subject
June 30 (cont'd)		
Wilbur Hall	12 00 - 12:30 p.m.	Lunch
Kresge Auditorium	2:00 p.m.	CORSE Summary and Adjourn

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General Instructions for

CORSE-78
Stanford University

Registration - Crothers Hall, Sunday, June 25, 4 - 8 p m
Kresge Auditorium, Monday, June 26, 8 a.m - 3 p.m.

Papers and Workshops - Locations and times as noted in Agenda

Message Telephone Number - (415) 497-3297

Parking on Campus at selected locations for cars with temporary passes issued at registration. Crothers Hall parking lot is recommended.

Evening Sessions are available to view slide/cassette programs for teaching remote sensing and related subjects. Meeting rooms in Tresidder Memorial Union will be used. The Purdue set of slides and cassettes as well as others will be available.

Exhibits/Trade Show is located in Rooms 281-282, Tresidder Memorial Union, and will be open from 8 a.m to 5 p.m , Monday, June 26 through Thursday, June 29. Class notes, exercises and other classroom materials submitted by participants will be on display along with trade exhibits

Instructions for Meal Service

CORSE-78
Stanford University

Participants with Wilbur Hall Meal Tickets

Meals must be taken during the following periods.

Breakfast	7:00 - 8:00 a.m.
Lunch	12:00 - 12:30 p.m.
Dinner	5:30 - 6:30 p.m.

Conference meal service at Wilbur Hall is from Monday, June 26, breakfast, through Friday, June 30, lunch, except Wednesday, June 28 dinner, which will not be available because of the Conference banquet at the Stanford Faculty Club.

Meal tickets will be issued at time of registration for faculty members from the 14 Western States who are staying in campus residence halls--Crothers and Stern. No individual meals will be provided...we have arranged for meals only as a package with residence for the full week.

Participants without Meal Tickets:

Meals may be taken at your own expense at Campus facilities such as in Tresidder Memorial Union and in Encina Commons Coffee Shop. Both facilities are shown on the campus map. Encina Commons is adjacent to the north of Crothers Hall. Tresidder Memorial Union parking lot is on Mayfield Avenue, southwest of Crothers Hall and west of Kresge Auditorium. Encina Commons Coffee Shop is open from 8 a.m. to 5 p.m., serving lunch only and coffee/pastries during the day. The main cafeteria in Tresidder Memorial Union is open from 8 a.m. to 6 p.m., closed Sunday.

<u>Cocktail Party and Banquet</u> - Wednesday, June 28 at Stanford Faculty Club, located on Lagunita Drive off Mayfield Avenue, west of Tresidder Memorial Union.

<u>No-Host Cocktail Party</u> - 6:00 - 7:00 p.m.
Drink tickets available at the Faculty Club
Drinks: $1.25 Wine: 75¢

<u>No-Host Banquet</u> - 7:00 p.m.
By reservation - payable at registration no later than Monday, June 26

Multimedia Workshop

Joseph J. Ulliman
University of Idaho

Introduction

Multimedia workshop sessions were held Wednesday from 1-4 pm and Thursday from 8.30-11:30 am. On the panel were Dr. Ronald L. Danielson, Assistant Professor, Dept. of Electrical Engineering and Computer Science, University of Santa Clara, Shirley M. Davis, Education and Training Specialist, LARS, Purdue University, and Dr. Joseph J. Ulliman, Associate Professor, College of Forestry, Wildlife and Range Sciences, University of Idaho, Chairman of the Workshop. Those attending the workshop who could be identified at one time or another are listed in Appendix A.

Objectives

The objectives of the workshop were:

a. To discuss the status and determine the availability of media in remote sensing.

b. To bring out the advantages and limitations of various multimedia and machine aided approaches to teaching.

c. To discuss problem areas.

d. To determine needs.

e. To discuss costs.

f. To make recommendations to NASA.

Being an informal workshop, it was realized that not all of these objectives would be completely met. It was understood also that many of the objectives were pursued in the paper presented Tuesday on Multimedia and Teaching Machines in Remote Sensing which is included elsewhere in these proceedings.

Media Demonstration

In addition to the workshop, certain media materials and devices were demonstrated on Monday and Tuesday evenings and explained in some detail during the workshop sessions. Shirley Davis and David Paine (Oregon State University) demonstrated their slide-tape programs to a number of interested people on those first two evenings of the conference.

Media Questionnaire

A media questionnaire was distributed during the conference to get some idea of the use of different types of media and what media might be generally available to the remote sensing community. There were 31 responses to the questionnaire, the results of which are included in Appendix B.

References

Other useful reference material which came to light during the course of the conference is listed in Appendix C.

Workshop Presentations

The workshops began with the chairman noting the objectives and emphasizing some of the points from the multimedia paper presented Tuesday, especially problem areas, disappointments and goals of particular media and some needs for the future. Ron Danielson followed with a presentation on "Computer Applications in Remote Sensing Education" which is included as a separate paper in these proceedings. Shirley Davis then discussed the media aids used in training programs at LARS, how they are developed, and gave some advice for individuals who wish to develop their own programs. Her presentation is also included as a separate paper elsewhere.

Workshop Discussion

The following discussion from the workshop is transcribed partially from written notes taken at the workshops and from recorded cassette tapes. All pertinent comments are recorded, although not verbatim, except those that are not understandable on the tape. Names are associated with comments where the person was recognized.

Key words from the objectives are associated with a comment where appropriate.

Wednesday, June 28

Comment: (PROBLEM) Remote sensers are so wrapped up in remote sensing they don't have the time to develop computer expertise or capability.

R. Danielson: (PROBLEM) Computer programs or instructional material are not publishable material and therefore it is not cost effective in the use of instructor's time to develop them.

S. Davis: (QUESTION) If CAI and CMI material existed, would you use it? (Some answered they would.)

J. Ullman: (STATUS) Doing exams with the computer is one possibility.

R. Danielson: (PROBLEM) Security of exam questions and identifying the examinee is a problem.

Comment: (STATUS) Computers can be used to grade exams.

S. Davis: (QUESTION) Does anyone else have access to PLATO? (Those from Oregon State Univ. stated they did.)

R. Danielson: (STATUS/AVAILABILITY) PLATO has 1008 terminals. CDC is going commercial with PLATO in a number of learning centers; one is in Sunnyvale by AMES where one can go and pay for a terminal; (DISADVANTAGE/COST) cost for contact time is high; you can get PLATO to play on CDC machines but I don't think you can get access to the lesson material. Development of programs by individual departments is not likely either. It takes 50 hours minimum to develop programs for one hour contact time. Funding for such development is mainly done by major funding agencies.

J. Ulliman: (RECOMMENDATION) A conference is a meeting where we should be out doing the things we're talking about. Possibly NASA could fund or assist in developing CAI programs, especially now that Ron Danielson is working for them part time.

S. Davis: (COST) Speaking of time it takes to develop programs, we estimate it takes 200-300 hours just to develop one mini-course.

Comment: (ADVANTAGE) In doing mini-course type programs, there is some advantage to having the non-specialist do the narrative portion and thereby provide some personality identification.

S. Davis: (ADVANTAGE/DISADVANTAGE) Two or three of our mini-course tapes were narrated by someone on our staff. We have not done a critical evaluation of the difference but we do know that ITC people have objected to the strong midwestern accent. For local use though, the instructor probably should make the tape in order to personalize it for the student.

Comment: (PROBLEM/RECOMMENDATION) Some students would rather read narrative than listen to the tape; give the student an alternative by providing the script also.

Comment: (AVAILABILITY) Cassette driven Super 8 film system can be projected as motion picture or individual frame for programmed paced instruction; you can adjust program speed anywhere from single frame to full motion; I do not know if anyone has done this, but it does seem to have possibilities.

S. Davis: (AVAILABILITY) Purdue will be developing more mini-course series: one on visual interpretation of thermal imagery; one on collection of field data; another on geologic image and numeric interpretation of satellite data -- this will not be a detailed how-to-do-it program but will present concepts, principles and theories; another on the basic principles of photo interpretation, including stereoscopy, parallax, scale, flight planning, etc.; and lastly one on computer processing. (Responding to a question) Yes, it is a team effort to develop materials; for example, I'll work with the geologist to develop the mini-course on geology.

J. Ullman: (NEEDS) Some people have expressed the need for large screen displays for larger audiences.

R. Danielson. (AVAILABILITY) In fact, some are using the large 76 square foot Advent TV screens like those used for boxing and football presentations.

R. Kiefer: (PROBLEM/ADVANTAGE) There is a great difference in users and some lectures are never given twice; it is difficult for me to see how slide/tapes, which essentially sets an established course, can be adventageous in such circumstances. I can see where slide/tapes would be good for student review purposes - when a student's sick or out of town, and that the slides might provide more illustrations than a text.

S. Davis: (RECOMMENDATION) Instructors could record lecture and keep their slides together in order to have available to students for review.

R. Kiefer: (DISADVANTAGE/ADVANTAGE) I am traditional and think you lose personal contact with slide/tapes. One could use slide/tapes to help explain what a conference is all about to those people who come early to a conference.

R. Whitmore: (STATUS) I have studied the audio-visual setups at Oregon State Univ. and Purdue and have developed a modular instructional approach for my course on Mechanical Properties of Wood. It consists of a series of modules which may be a combination of traditional lecture or labs, films, video tapes, independent study materials, etc.; we put some of the programs, including labs and demonstrations, on Super 8 film but most of it goes on color 3/4" video tape even taping slides and movie film. We expect the students to master the procedures. We will also be developing a remote sensing course using the same type of procedures.

S. Davis: (QUESTION) How has the roll of the professor changed between the two systems?

R. Whitmore: (ADVANTAGE/DISADVANTAGE) My contact with the students has greatly increased; there is much more one-to-one contact which is mainly my doing.

S. Davis: (ADVANTAGE/DISADVANTAGE) The instructor actually has to work harder and ends up with more student contact time. All these new terms -- self paced instruction, individualized instruction, etc. -- are overlapping terms and the techniques or methods are not a substitute for the instructor; the instructor's role is altered but he cannot put out his sign, "Gone Fishing", after developing audio-visual approaches.

R. Danielson: (ADVANTAGE/DISADVANTAGE) In the beginning computer programming course at the University of Illinois, 2000 students per semester use CAI; there is one hour lecture by a Professor, two hours of CAI, one hour lesson development, and one hour program practice along with lab sections. This is an enhancement to the traditional course and is as much or more work for the instructor than in the traditional courses.

J. Ullman: (ADVANTAGE/DISADVANTAGE) In developing AV approaches, the instructor is actually forced to do a better job; it is a very demanding process and the instructor must be very selective as to what is put on slides or tapes. I personally still spend much time in the lab to see how the student is doing, approximately seven hours per week; a TA also spends about 20 hours in the lab. There are some students who do not take responsibility for their own education and these have to be led by the hand; many of these students get behind and drop the course - up to 20%.

I talk to all of the students who drop and almost all admit they just did not do the work to keep up.

D. Paine: (ADVANTAGE/DISADVANTAGE) I had a high (50%) dropout rate in the AV course at first, but now have about a 75% completion rate.

R. Danielson: (ADVANTAGE) It is a good experience for anyone to sit down and write a set of behavioral objectives for a course and develop a programmed instruction set for a course.

R. Whitmore: (STATUS) Another thing I do which might be of interest -- I put a rheostat in an overhead projector and using gelatin filters project the light spectrum.

J. Ulliman: (STATUS) The paper presented Tuesday has a list of many sources for media materials; the EROS Data Center has a list for their materials and Purdue and NASA also have brochures. (RECOMMENDATION) Although most slide sets are not adaptable in their entirety to a local situation, individual slides and some sets may be appropriate. NASA could provide individual or sets of slides on such things as the U-2 and its operations or the LANDSAT satellite and all its systems close up.

T. Best: (PROBLEM) NASA may not have slides of such things because they are not taking them from a teaching point of view.

J. Ulliman: (RECOMMENDATION) That's a good point; recommend NASA consider it.

G. Hull: (STATUS/PROBLEM) NASA has 2000-3000 slides at their service center and a slide copier; how to service the community is the big question; how can the community access the collection?

Comment: (QUESTION) Is there any way in which the regional centers could be provided a circulating set for those in the local area?

R. Danielson: (STATUS) NASA has some beautiful display materials also.

J. Ullman: (QUESTION) Is there any way individual instructors could look through slide sets and request duplication of material?

Comment: (STATUS) We are not set up to do that.

S. Davis: (STATUS/RECOMMENDATION) EDC has slide sets available; possibly the other centers could do likewise.

J. Ullman: (STATUS) R. Jay Murray said he saw references to the stereo use of overhead projectors in a Chemical Education Journal and that one article referenced the commercial development of such projectors in Germany. (The citations to those articles are included in the references in Appendix C.)

Comment: (STATUS) We at U.C. Santa Barbara use CCTV to zoom in on LANDSAT scenes on CRT; this is especially good for large audience viewing.

R. Kiefer: (STATUS) When we do computer analysis for workshops and short-courses, and especially for people coming from out of town, and the computer goes down right in the middle of an operation led us to tape things ahead of time; that way we know its going to work.

R. Danielson: (RECOMMENDATION) How many have access to video tape players? (A few responded, yes.) It might be a good idea to survey what tapes are available and make it known to the community, even if they are of different formats.

R. Kiefer: (STATUS) Almost all campus' have some form of video tape players available which an instructor should have access to.

J. Ullman: (STATUS) EDC has a number of video tapes available.

R. Kiefer: (PROBLEM) This is a personal thing but I have been grappling with the problem of providing slide sets for the line drawing and B & W and color pictures for my forthcoming book. Will it be a service to people or can they do it themselves; as far as I'm concerned people can take their own pictures.

Comment: (COSTS) If you did provide slides, they would have to be very inexpensive.

J. Ulliman: (RECOMMENDATION) I would promote the idea of making complete sets of both 35 mm slides and transparencies if they were inexpensive.

Comment: (AVAILABILITY/COST) I have 36 slides made up from a negative for \$3.00. When I get 4 to 5 requests for an item, I take a shot of it with Kodacolor and send the negative off to RGB Color Lab, 816 N. Highland Ave., Hollywood, CA 90038. They make positive transparencies of it from old outdated movie film; they use the loop film for as many copies as needed. The negative/positive approach like this may be the way to beat the inventory problem.

S. Davis: (STATUS) LARS set up a remote computer network project in 1975 to 6 to 8 terminals around the country for education and research purposes to train users in the theory behind computer analysis and how to use the computer. LARS also offers shortcourses directed to the analysis of multispectral scanner data and numerical analysis. These are individualized self-directed courses, not self-instructed, week long courses in which a variety of media are used.

J. Mairs: (RECOMMENDATION) We have given workshops for agency people using CAI. NASA could help by providing funding to rework programs so they will be more institutional in nature; that would be one way for NASA to promote remote sensing education.

<u>Thursday, June 29</u>

N. Short: (NEED) Can we get people familiar with the computer in three days, possibly using video tape.

R. Danielson: (STATUS) A discipline person does not need to be a computer programmer but should know the capabilities of the computer.

C. Metz: (QUESTION) We have PLATO at Oregon State University in the Music Department; could we not get on that system.

R. Danielson: (AVAILABILITY/COST) Yes. Telephone calls would be a cost and you would have to develop your own programs; best thing would be to contact a sales representative to develop programs. EXXON has CAI/CMI programs also.

C. Metz: (NEED) We have slides of scenes and want to best get across an idea; is it best to put words or a word on the slide itself?

N. Short: (STATUS/AVAILABILITY) You could have two slides - one as is and another with a word on it. NASA has one of the largest collections of slides in the world (and it is in the public domain) and would like to see them utilized. It's easy to make your own slide shows; Kodak makes a camera which fits over any 8" x 10" picture. You can produce shows by taking a standard lecture which uses slides and where the instructor is giving a spontaneous talk - tape record the lecture and keep the shown slides in order; coordinate the narrative and the slides for future use.

W. Limoine: (PROBLEM) My opinion of the slides used in the conference is pretty low.

Comment: (NEED) If there are any aids or guides for producing good slides they should be given to NASA.

Comment: (AVAILABILITY) Anyone can come and look at the slides NASA has; you can also look at the slides at the USGS Menlo Park facility.

J. Ulliman: (NNED) What about people who can't get to the facility; can provisions be made, for example a catalog of available slides?

N. Short: (STATUS) The 1st semi-annual meeting of training officers of the three NASA regional centers was held yesterday; a decision was made for each of the three centers to prepare several master set copies of slides used frequently and exchange these sets with the other centers; we would also get a brief description of each slide for a caption. I proposed a teachers guide showing B & W copies of each slide which an instructor can look at. This is basically for in-house work but I will look for some mechanism to get slides out to the public.

Comment: (STATUS) We do take slides to national conventions, like the National Science Teachers Convention, for others to see.

Comment: (ADVANTAGE) After seeing a multimedia, 6 projector presentation I was really impressed.

D. Shinn: (ADVANTAGE) Using more than one projector is useful for showing multidate imagery or simultaneously a LANDSAT, U-2 and ground scene image of the same area.

N. Short: (STATUS) Most national conventions are using two projector setups.

J. Ulliman: (PROBLEM) What is the amount of effort required for six-projectors compared to the added information content or the message gotten across?

Comment: (ADVANTAGE/DISADVANTAGE) I am really excited about it; you do need lots of slides and it is used more at the entertainment level rather than educational; it takes 20-30 minutes to set up but it really has a dramatic impact.

S. Davis: (STATUS) Our objective at Purdue is to make a product as portable as possible and easily used by most people.

J. Ulliman: (STATUS) Multimedia six-projector demonstrations are great for gee-whiz presentations and for influencing opinions, etc. but have not proven their usefulness for instructional purposes although they could be developed for that goal.

J. Smith: (STATUS) On the life of materials - some basic material may be good for 20 years.

S. Davis: (STATUS/RECOMMENDATION) The life of most materials is short; we are committed to reviewing ours in three years; I would suggest others do the same.

N. Short: (STATUS/PROBLEM) We have made three video tapes and have only been moderately successful; the problem is amount of time to properly develop them. We taped our last course and duplicated the slides.

B. Schrumpf: (NEED) I would like to see some well documented 20-40 minute color films produced on such subjects as, for example, the history of remote sensing, the basic energy-matter relationships, and sensor systems; some organization could do this and provide the films at a regional lending library.

N. Short: (AVAILABILITY/PROBLEM) We tried to make a video tape history of remote sensing and asked Bob Colwell to do it; time was a problem and prior planning was lacking; Bob gave an excellent presentation but it was more on "Aircraft remote sensing in California" than what we wanted - LANDSAT; the tape of that presentation is available for anyone who wants to borrow it. We are going to do two video tapes in the next six months to a year; one will be a 45 minute tape on "field observations" -- there are many people involved in developing sensors who are doing much ground work and training site selection; the other video tape will be a case history of an agency getting into remote sensing and developing an operational activity. There are problems video taping lectures; slides and other AV material must be spliced into the tape separately; its difficult to get good close ups of items off screen.

S. Davis: (STATUS/RECOMMENDATION) One way to solve that is to use a rear screen projection although that presents another problem of a hotspot on the screen. Another way is for the video production managers to have slides under his control and another video camera to view the slides; the lecturer can see the slides on a monitor. Another method is using over-the-desk mounted cameras where the instructor has control over the process. I strongly encourage those developing modules, especially when working with others, to develop definitive objectives so that the student knows exactly what is expected of him when finished; this can be an excruciating experience; if two people are working together it can be a discipline experience forcing the creators to know exactly what they are going to do.

Comment: (RECOMMENDATION) National Geographic does some outstanding films; that may be the type of thing you should shoot for in developing film like Barry Schrumpf mentioned.

N. Short: (STATUS/AVAILABILITY) Through the single-handed effort of Chuck Poulton who has gotten National Geographic into LANDSAT, the July issue will have a beautiful LANDSAT mosaic map of the Grand Canyon; they are starting to use LANDSAT in the ongoing National Geographic Lecture Series; I will ask Chuck to see if National Geographic will be interested in developing a movie. Our video facility is looking for work and I am looking for ideas for using that facility, so if you have ideas, let me know and I'll consider them.

D. Shinn: (STATUS) In the alternatives for the Washington program, which was a planning rather than remote sensing effort, KWSU video taped in color all the planning sessions. Tapes were used to inform other people involved in the effort but who were not at those sessions. The tapes were then edited into 8 hour long programs to be televised statewide. Finally they produced a highly edited film which was then submitted as one of the US entries in the UN Habitat Conference held in Vancouver.

J. Ulliman: (ADVANTAGE) When developing programmed and self-instruction packages it is a very rigorous process which is the best aid to improving instruction I know of.

R. Schultz: (DISADVANTAGE) You may also run the risk of becoming so highly organized that you go too fast in presenting material that the student can't keep up.

S. Davis: (ADVANTAGE) It is an advantage of self-paced instruction -- many have criticised our mini-courses because they go too fast, others have appreciated the stepped up pace -- if someone misses something they can always go back and listen to it over again. I would like to also ask you not to forget that print is a media also; we have developed some materials along this line.

N. Short: (AVAILABILITY) We get some requests for slides of plates from the book Mission to Earth. About 150 of the plates are on slides. There is a source of 8" x 10" color prints themselves in the Public Affairs Office, NASA Headquarters, but the quality is not the best.

Comment: (STATUS) We have inexpensive way of reproducing 9" x 9" B & W's. At AV Center we made an 8½" x 11" negative using a dot screen and then make an offset plate. We can get about 500 copies for $6.00 and of relatively good quality. We also do this for LANDSAT scenes.

N. Short: (RECOMMENDATION) Recommend you do two things: share funding for development of programs; and, identify a clearinghouse for obtaining materials.

S. Davis: (NEED) What we need is an information clearinghouse.

N. Short: (STATUS/AVAILABILITY) There are 20-30 newsletters floating around; two LANDSAT newsletters, one from Goddard and one from EDC, which have fairly wide distribution; if you have an educational announcement you can go through me because one of the members of my carpool is the editor and I can guarentee you instant access.

J. Ulliman: (RECOMMENDATION) Since NASA now involved in education, it might be a good idea to have a special newsletter to get across ideas on instructional technology, sources of materials, etc.; each instructor in remote sensing would get a copy of the letter and at the same time could provide information for the newsletter.

Comment: (PROBLEM) Such a letter though would probably be restricted to LANDSAT.

D. Shinn: (AVAILABILITY) Robin mentioned the newsletter, "Plain Brown Wrapper".

N. Short: (RECOMMENDATION) All three centers could have their own newsletter.

J. Ulliman: (RECOMMENDATION) There should be some coordination between the three centers and pass some information around nationally rather than just in the region.

Comment: (ADVANTAGE) The three centers are competing and this is desirable.

Appendix A

List of identified attendees

NAME	ORGANIZATION	ADDRESS	TEACHING INTEREST
Tom Best	Survey, CSU	Los Angeles, CA 90032	Geographic Media
B. Michael Donahoe	NASA Ames	Moffett Field, CA 94035	Service to Educators
Donald R. Floyd	Calif. Polytech. State University	San Luis Obispo, CA 93401	Geography
Garth A. Hull	NASA Ames	Moffett Field, CA 94035	
Ralph Kiefer	Univ. of Wisconsin	1210 Engr. Bldg. Madison, WI	RS and API
Ken Knothe	Treasure Valley Community College	Ontario, OR 97914	Applic. for Forest-Range Field Use
Bill Lemoine	Southwestern Oregon Community College	Coos Bay, OR 97420	Aerial Photos, Forestry & RS
Joseph Lintz	Univ. of Nevada	203 Mackay Mines Reno, NV 89517	R/S
John Mairs	ERSAL - OSU	Corvallis, OR 97331	Geography, PI & RS
Charlene Metz	Oregon State Univ.	Corvallis, OR 97331	Forestry & RS
Charles Nelson	Chico State	Chico, CA 95929	Geography
David Paine	Forest Mgt. Dept. Oregon State Univ.	Corvallis, OR 97331	Biometrics, PI & RS
Barry Schrumpf	ERSAL - OSU	Corvallis, OR 97331	RS in Resource Anal.
Robert J. Schultz	Civil Eng. Dept. Oregon State Univ.	Corvallis, OR 97331	Civil Engineering & Surveying
Duane Shinn	Univ. of Washington	410 Gould Hall, JO-40 Seattle, WA 98195	Land Use & RS
Nick Short	NASA Goddard	Greenbelt, MD 20770	Training
Jim Smith	Colorado State Univ.	Fort Collins, CO 80521	RS Computer Applic.
Moyle D. Stewart	US Geological Survey	345 Middlefield Rd. Menlo Park, CA 94025	
Frank Westerlund	Univ. of Washington	Seattle, WA 98195	RS Applica. to Land Use
Roy Whitmore	Dept. of Forestry Univ. of Vermont	Burlington, VT 05401	Forestry, PI & RS

Appendix B

Results of the Media Questionnaire

1. Use of Media

Quantitative results of the media questionnaire are included in Table 1. Of those responding, it appears most everyone uses slides, stereograms and overhead transparencies to some extent. Very few or no instructors use videotape, models, stand-alone audio tape, and computer assisted instruction (CAI). Apparently some do not use media materials even though they have them available either in their own labs or somewhere within their organizations; possibly, the materials in question are not of the proper subject material or quality to suit the instructor because, at the same time, most indicated they would use good quality materials if they were available at a reasonable cost. Most respondents also specified that they would make any media materials they developed available to others.

2. Availability of Media Materials

Many respondents made some comment that their materials were locally developed and not generally available to others because they are either not organized, not of sufficient quality or are limited to the local situation.

Those who have or could make materials available are:

a. Department of Continuing Education, Portland State University, Portland, OR.
Program: Forest Technician Series (1974-1975) Aerial Photogrammetry.

b. Crane S. Miller, California State Polytechnic University, 3801 W. Temple Ave., Pomona, CA 91768. Tele. (714)598-4513 or 4516.

Dr. Crane has developed a number of 35 mm slide sets on various aspects of remote sensing which he uses in his classes. Much of the material is not original although many slides are original

Table 1. MEDIA QUESTIONNAIRE
(Software Only)

Number of responses: Y = yes; I = infrequent; N = no.

Media	Do you use this media			Do you have this media in your remote sensing lab		If you developed or own this media would you make it available to others		If you do not have or own this media, is it available through your organization		If you do not use this type media, would you use it if good quality resonable priced items were available	
	Y	I	N	Y	N	Y	N	Y	N	Y	N
a. Videotapes	0	5	22	5	19	14	3	9	8	16	2
b. Slide sets	24	5	0	26	0	23	3	7	3	9	1
c. Stereograms	17	8	5	24	3	20	5	6	5	9	2
d. Models	1	7	17	8	15	14	4	4	10	12	3
e. Overhead transparencies	18	7	5	24	2	19	4	9	3	9	1
f. Audio tape	2	4	18	5	18	14	3	6	9	11	5
g. Slide/tape programs	5	7	13	12	11	17	2	9	8	16	2
h. CAI programs	2	2	19	3	18	13	2	2	8	10	4
i. Other programmed instruction sets	0	1	13	2	8	9	2	3	6	9	1

true and false color photos taken by his personnel. Subjects covered are: Overview of Remote Sensing (with cassette sound); Photo and Non-photo Sensors; Scale; Geomorphology; Forestry and Vegetation in General; Agriculture; Urban Land Use; and, Archeology. Dr. Crane would be interested in further development of such sets for anyone interested.

c. R. Jay Murray, ERSAL, Oregon State University, Corvallis, OR 97331. Tele. (503)754-3056.

   Has developed FORTRAN programs for CDC equipment to classify LANDSAT data, select training sets, etc. These could be made available for cost of materials and copies.

d. Robert M. Newcomb, Dept. of Geography, California State Univ., Northridge, CA 91330. Tele. (213)885-3532.

   For those interested, Dr. Newcomb has a list of "Selected LANDSAT Photographs of Denmark" available from the EROS Data Center as of Winter 1976/1977 with comments on coverage and quality.

e. Floyd Sabins, (UCLA, USC, Chevron) Box 446, La Habra, CA 90631. Tele. (213)691-2241, Ext. 2370.

   Floyd Sabins is currently preparing a lab manual to accompany his new text, "Remote Sensing, Principals and Interpretation". He is also considering developing a slide set to accompany the text and a slide set to accompany the instructors guide for the lab manual.

f. Duane Shinn, Urban Planning JO-40, University of Washington, Seattle, WA 98195. Tele. (206)543-1508 or 4190.

   Dr. Shinn has two slide sets available:

   (1) "Remote Sensing of Land Use for Noise Abatement" (USAF); 192 color 35 mm slides developed March 1978 of variable quality; a case study with results of Fairchild and McChord AFB.

(2) "Introduction to Remote Sensing"; 160 color 35 mm slides developed March 1978 of excellent quality; current state-of-the-art review on PNRC Project covering sensors, data and products.

g. Everett Wingert, Dept. of Geography, Univ. of Hawaii, Honolulu, HI 96822. Tele. (808)948-8463.

Has over 100 overhead transparencies, mostly of LANDSAT and aerial images. Also has contact size negatives of these both in halftone and continuous tone. He does not have a complete list of the transparencies or a mechanism for reproducing them commercially. If others are interested though he would make special arrangements for getting duplicates.

3. Other Possibilities

Some other instructors in remote sensing may have media materials although they were not at the conference, nor were they surveyed to determine exactly what they had. Their names were listed as people who have media materials and might want that fact to be known.

a. Dr. David Simonett, Dept. of Geography, UCSB.

b. Dr. John Jensen, Dept. of Geography, Univ. of Georgia, Athens, GA.

c. Dr. Jon Kimmerling, Dept. of Geography, Oregon State Univ.

d. John Harper and Bob Plank, Dept. of Geography, Humboldt State Univ.

e. Dr. Mel Stanley and Dr. James Huning, California State Polytechnic Univ.

f. Pacific Northwest Regional Commission Land Inventory Demonstration Project, 1205 Washington St., Vancouver, WA 98660.

Appendix C

1. Catalogs, Mimeographs, Pamphlets, Workbooks

Announcing a New Series of Slide-Tape Presentations on Using Aerial Photography for Natural Resource Management. Forestry Media Center, Oregon State University, Corvallis, Oregon. (Pamphlet)

EROS Data Center Workshop. Exercise File. June 15, 1978. 21 pp. (Mimeograph)

Film Catalog 1978-1979. NASA Ames Research Center, Moffett Field, CA 94025. (Catalog)

Mini-Course Series on Fundamentals of Remote Sensing by the Laboratory for Applications of Remote Sensing. Purdue University, West Lafayette, Indiana. (Pamphlet)

NASA Educational Publications. Aug. 1976. NASA, Washington, D.C. 20546. (Pamphlet)

Secondary School Social Studies Project "What's the Use of Land?" by the Jefferson County, Colorado, Public Schools. NASA, Wash., D.C. 20546. 57 pp. (Workbook)

2. Other References

Clarke, Paul F., Helen E. Hodgson, and Gary W. North. 1978. A Guide to Obtaining Information from the USGS. 1978. Geological Survey Circular 777.

Crozat, Madeleine M. and Steven F. Watkins. 1973. Overhead Projection of Stereographic Images. Journal of Chemical Education 50(5): 374, 375.

Hayman, H. J. G. 1977. Stereoscopic Diagrams Prepared by a Desk Calculator and Plotter. Journal of Chemical Education 54(1):31-34.

Nixon, W. D. and R. E. McCormack. 1977. LANDSAT: A Tool for Your Classroom. Reprint from: Social Education Official Jor. of the National Council for the Social Studies. Nov-Dec. 1977.

Ophir, D., B. J. Shepherd, and R. J. Spinrod. 1969. Three-Dimensional Computer Display. Communications of the ACM 12(6):309, 310.